Exhibit C-7-1A

BEFORE THE

OIL AND GAS CONSERVATION BOARD

PROVINCE OF ALBERTA

IN THE MATTER OF THE GAS RESOURCES PRESERVATION ACT, BEING CHAPTER 19 OF THE STATUTES OF ALBERTA 1956.

MATERIAL FILED ON BEHALF

OF THE

CITY OF CALGARY

RESPECTING EXPORT OF NATURAL GAS

FROM THE PROVINCE OF ALBERTA.

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TO:

The Oil and Gas Conservation Board,
Calgary, Alberta.

LETTER OF TRANSMITTAL

The attached material is filed with the Board in support of the position of the City of Calgary respecting the pending application of Westcoast Transmission Company Limited and Alberta and Southern Gas Co. Ltd. to export gas from the Province of Alberta.

The said material is also relevant to any other application which may be made to export gas from the Province of Alberta.

Evidence will be adduced to support the said material.

Attention is drawn to the provisions of the Gas Resources Preservation Act whereby certain mandatory statutory duties are imposed on the Board. Reference is made in particular to the following provisions:

> "3. The intent, purpose and object of this Act is to effect the preservation and conservation of the oil and gas resources of the Province and to provide for their effective utilization having regard to the present and future needs of persons within the Province."
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> "8. (1) The Board shall inquire into and hear the application and, with the approval of the Lieutenant Governor in Council, may
>
> > (a) grant a permit for such period and subject to such other terms and conditions as the Board may prescribe."
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Attention is drawn to the provisions of the Gas Resources Preservation Act whereby certain mandatory statutory duties are imposed on the Board. Reference is made in particular to the following sections:

> "2. The intent, purpose and object of this Act is to effect the conservation and prevent the waste of the oil and gas resources of the Province and to provide for their efficient utilization having regard to the present and future needs of persons within the Province."

> "5. (1) The Board shall inquire into and consider any application and, with the approval of the Lieutenant Governor in Council, may
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> (a) grant a permit for such period and subject to such other terms and conditions as the Board may prescribe;
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> . . . .

> " (3) The Board shall not grant a permit for the removal of any gas from the Province unless in its opinion it is in the public interest to do so, having regard to

(a) the present and future needs of persons within the Province, and

(b) the established reserves and the trends in growth and discovery of reserves of gas in the Province."

. . . .

"9. Without limiting the generality of clause (a) of subsection (1) of section 8, the terms and conditions prescribed in a permit may include

(a) the pool, field or area from which the permittee may remove gas or the point at which the permittee may remove gas from a pipe line in existence or to be constructed,

(b) the annual quantities of gas that may be removed by the permittee from each pool, field or area or from such pipe line during the interval or intervals set out in the permit,

(c) the maximum quantity of gas that may be removed daily from each pool, field or area designated in the permit or from such pipe line,

(d) the conditions under which the removal of gas by the permittee may be diverted, reduced or interrupted,

(e) a condition that the permittee will supply gas at a reasonable price to any community or consumer within the Province that is willing to take delivery of gas at a point on the pipe line transmitting the gas, and that, in the opinion of the Board can reasonably be supplied by the permittee,

(f) the period for which the permit is operative."

The City of Calgary does not oppose the export of natural gas provided that its position relative to the supply of natural gas is

amply protected. Such protection includes:

(a) that provision be made for the requirements for natural gas for all present and future needs of the persons living in Calgary for at least a period of 30 years,

(b) that this supply of gas be safeguarded by setting aside for such purpose gas fields already discovered in the near vicinity of Calgary without the necessity of the construction or use of costly pipe lines,

(c) that future gas sources which may be found which can supply economically gas for the inhabitants of Calgary be dedicated for the supply for Calgary,

(d) that a fair price be fixed for such natural gas which price shall not reflect the export demand and that corporations seeking to obtain export shall be required to supply gas at such price,

(e) that the Board make such orders and directions as are necessary to give effect to the foregoing.

DATED at the City of Calgary, in the Province of Alberta, this 16th day of January, A.D. 1958.

Respectfully submitted,

THE CITY OF CALGARY

"S.J. HELMAN"

"E.M. BREDIN"

Of Counsel for the City of Calgary.

amply protected. Such protection includes:

(a) that provision be made for the requirements for natural gas for all present and future needs of the persons living in Calgary for an ample period of 30 years,

(b) that this supply of gas be safeguarded by setting aside for such purpose gas fields already discovered in the near vicinity of Calgary without the necessity of the construction or use of costly pipe lines.

(c) that future gas sources which may be found which can supply economically gas for the consumers in Calgary be dedicated for the supply for Calgary.

(d) that a fair price be fixed for such natural gas which price shall not reflect the export demands and that corporations seeking to obtain export shall be required to supply gas at such price.

(e) that the Board make such orders and directions as are necessary to give effect to the foregoing.

DATED at the City of Calgary in the Province of Alberta this 16th day of January, A.D. 1951.

Respectfully submitted,

THE CITY OF CALGARY

"D.P. McDONALD"

"D.ML. NOLAN"

Of Counsel for the City of Calgary.

January 9, 1958.

S.J. Helman, Q.C.,
800 Lancaster Building,
CALGARY, Alberta.

Dear Sir:

Four technical reports have been prepared and are attached. The reports deal with various phases of the matter of the price and supply of natural gas to Calgary consumers, and other consumers on the Canadian Western Natural Gas System from Calgary to Lethbridge, Lethbridge to Taber, and Lethbridge to Cardston.

Mr. Martin, in his report, has shown a marked increase in population over the figures used by the Canadian Western Company. The annual consumption figures used in my report are those projected by the Canadian Western Company in Exhibit 24. The annual increase in consumption is 2.6 BCF in 1960, and has been continued at that same amount each year for thirty years.

This means in effect that the more people in a metropolitan area, the lower the annual increment of population, and the lower the rate of industrial growth. This assumption is not a sound one, and is in fact likely to be proven incorrect. The larger the population, the greater the growth of industrial consumption of fuel, is a sounder conclusion.

Time did not permit a recalculation of the Canadian Western requirements based upon Mr. Martin's data. Mr. Martin and myself completed our respective reports at the same time. I believe that the requirement data shown in Exhibit 24 is too low by a substantial amount.

Mr. Workman and Dr. Flock have examined the Calgary Field in detail; and their evidence will show, that the marketable natural gas reserve is about half that estimated by the Westcoast Transmission Company. Even this estimate will depend upon the cost of wells, cost of producing them, and the revenue to be derived from them. Sulphur is the largest single product. It is quite possible that the production per well will be too small in the year 1980 to warrant further drilling.

A plan for the future supplies of gas to Calgary has been put forward by the Canadian Western Natural Gas Company Limited. It included the purchase of gas rights at Carbon, the reserve of which was estimated by Canadian Western at 206 BCF. A price for proven

land was set at $800.00 per acre, and for probable acreage at $300.00. Any acreage could be changed from probable to proven by the drilling of one well per section of land. The cost of drilling a well at Carbon, completed for production, is approximately $80,000.00. The total acreage involved is by Canadian Western estimate 19,000 acres, or 30 sections. The option with Shell Oil Company covers 5168.2 proven and non-proven acres. Any other contracts held by Canadian Western covering acreage in this area have not been produced to this date.

It has been proposed that Carbon would be used to supply peak load, and a 16-inch OD pipeline to Calgary would be built at a cost of $2,700,000.00. Another pipeline, twenty miles long, would have to be built from Calgary to a point on the Sarcee Reserve, to connect with the Alberta Trunk Line. This line might have to be a 20-inch OD line, and its cost will have to be considered.

The general idea behind the proposed Canadian Western plan was that gas would be purchased from Alberta and Southern on a 70% load factor basis, and the consumers of gas in Southern Alberta would pay all the cost of making this possible. The alternative offered is that Canadian Western would buy gas from Alberta and Southern at a price 1.3 times the weighted average field purchase price, paid by Alberta and Southern.

My objection to the proposed Canadian Western plan is based upon the fact that space heating consumers on the Canadian Western system are penalized because they use more gas in winter than in summer. The Calgary system has a low load factor, of around 35% for space heating, and just over 40%, when industrial consumers are included because of cold winter days. Load factor is defined as the average consumption per year divided by the consumption on the coldest day of the year.

It is my opinion that there should not be any penalty to the Canadian consumer for load factor in any contract between an American export company and an Alberta producer. The gas reserve is located in Canada, and not in the United States, and no consumer in Canada should have to pay more in any gas field for gas than any other consumer. An example is the Sarcee Field, now under contract to Alberta and Southern Gas Company Limited. At a load factor of 70% the price is the weighted average field price paid by Alberta and Southern; but Canadian consumers need this gas at a lower load factor than 70%. The price to be paid to Alberta and Southern would then be 1.3 times the weighted average field price paid by Alberta and Southern. The consumers in Southern Alberta should not be the victims of any such discrimination, especially so in this case, as the

gathering and treating of the Sarcee gas, as shown in my report, could be handled in the most efficient manner by the existing Madison Natural Gas Company plant at Turner Valley, and become part of the Turner Valley system.

Calgary consumers have been paying for large gathering lines, treating plants, and for wells for forty years; and they can continue to do so in future, without any large and unnecessary expenditure in the years 1958 and 1959, relating to the Carbon Field development.

The Calgary consumers should not have to depend upon any export pipeline for gas; but should have clearly defined gas reserves dedicated solely for the use of Southern Alberta consumers. These reserves should include the Foremost, Bow Island, Okotoks, Calgary, Jumping Pound, Sarcee, Turner Valley, and Sundre - Westward Ho - Harmattan and Crossfield fields.

The reserve of 1220 BCF in the Sundre - Westward Ho - Harmattan - Crossfield area is classified at present as associated with crude oil production, and may not all be available until 1982. Because of this factor there may be some merit in the idea of building a smaller diameter line than 16-inch to Carbon to buy gas at so much per MCF. However, the length of the line for such a small reserve as 206 BCF will make it very expensive gas. In any event it would not be required until 1963.

It is my opinion that no corporation should have the right to set by contract any load factor in a gas purchase contract. Any such condition should be set by the Oil and Gas Conservation Board. If Canadian Western wishes to purchase gas from Carbon at a 10% load factor, that should be settled by the Board, and not by any contract.

The total gas reserves available, including all the gas fields near to treating plants at Jumping Pound, and Turner Valley, or to the transmission lines of the Canadian Western Company including Carbon amount to 3231.7 BCF. This includes 1220 BCF, which may not all be available until late in the 1980's. The estimated needs of the Canadian Western system amount to a minimum of 2273.6 BCF. The daily peak load, which is so important a matter to all consumers of gas on a -40°F morning, will amount to over 700 million cubic feet in 1987, and even in the year 1968 the peak day would require 400 million cubic feet. To supply a peak day of 700 million cubic feet will require substantial gas reserves, the whole capacity of which will be needed for winter months. The annual quantities sold will amount to over 115 BCF by 1987. The overall load factor of this

market in 1987 will be 42%.

It is estimated that to supply a peak load of this magnitude will require gas reserves of 4220 BCF. The Deliverability Table, given in my report, shows that 843 BCF will be used from Sundre - Westward Ho - Harmattan or Crossfield by 1987. If the Board should decide that this gas cannot be released until the oil has all been produced, then additional non-associated, low acid content gas will be needed by Southern Alberta consumers by 1963. The trend of growth, and the rate of discovery of reserves may provide sufficient marketable gas in the next five years to replace the Sundre - Westward Ho - Harmattan - Crossfield associated gas reserve.

The plan proposed in my report is designed to provide Southern Alberta consumers with an adequate supply of gas; and without any large and unnecessary increase in cost to them for some years.

Yours truly,

"S.J. DAVIES"

S.J. Davies, P. Eng.

PART A

Subsurface Geology of the Calgary Area with Special Reference to the Gas-Producing Formations

by

L.E. Workman, P. Eng.

Canadian Stratigraphic Service Ltd.

Calgary, Alberta

The geologic strata underlying Calgary down to the base of the Crossfield member of the Wabamun group of formations is shown in Figure 1. Of these the gas-producing rock units thus far discovered are the Basal Quartz sand, the Elkton lower porous member of the Turner Valley formation, and the Crossfield member. A cross-section A-B (Figure 2), extending in a west-to-east direction across the north-central portion of the map-area designated as the Calgary area in this report, shows the thicknesses and relations of these units to each other, and their attitude with relation to a horizontal base line 3000 feet below sea level.

The normal structure of formations in this vicinity, that have a fair uniformity of thickness and are parallel to each other, is shown by the map of the geologic structure of the base of the Exshaw shale (Figure 3; the Exshaw base is shown in the cross-section, Figure 2). This shows a practically flat surface rising due eastward between Bearspaw 22-9 and Beddington 8-34 at a rate of 97 feet per mile and from thence east-ward at a rate of 68 feet per mile.

Basal Quartz Sand

"Basal Quartz" is the term popularly used to designate the quartz sandstones which occur in the lowest portion of the Blairmore formation. These sandstones, having been deposited on an unevenly eroded old land surface by an encroaching sea, are very irregular and lenticular in occurrence, and vary from clean quartz sand to some salt-and-pepper (quartz-and-chert-grained) sandstones to argillaceous sandstones to sandy clays to clay containing very little sand. In very basal portions of the deposits pebbles and boulders of chert, which were remnants after weathering of the Mississippian limestones, commonly occur in any of these types of sediments.

In the Calgary area the following general succession of basal Blairmore deposits is recognizable, their unit thicknesses

being shown:

Lithology	Feet Thick
1. Sandstone, quartz containing some chert and glauconite grains, very fine to fine, mostly compact with calcite cement and some interstitial clay, varying in some localities to porous zones in which occasional spotted oil or tar shows are noted.	0 to 25
2. Sandstone, quartz, very fine to medium grained, compacted with a matrix of light to medium grey, cream, buff, light brown and, in places, red and yellow, putty-like clay; grades to sandy clay and some clay without sand.	0 to 100
3. Sandstone, quartz, very fine to fine to some coarse, in places conglomeratic with chert pebbles and boulders, more or less porous (Basal Quartz)	0 to 61
4. Shale, green, grey, waxy to putty-like, containing some sand and commonly many chert pebbles and boulders (Detrital Zone)	0 to 35

These four units are shown on cross-section A-B (Figure 2). They are variable not only in thickness but in composition, and in each there may occur lenses of porous white to grey quartz sand that might be of importance in gas production. However, Unit 3, which produced gas in the North Calgary 25-11 well appears from the present study to be the most persistent and porous sand body. Therefore, this is here described as the Basal Quartz sand, of importance to the City of Calgary for its gas possibilities and as a storage reservoir.

The areal distribution and thickness of the Basal Quartz sand is shown in Figure 4. The unit is not present at the location of the Delacour 5-3, Calgary 36-10, and Chestermere 18-11 wells but immediately to the northeast in Kathryn 3-2 and to the southeast at Shepard 10-15 thicknesses are 45 and 61 feet, respectively. Westward from the crescent-shaped edge thicknesses vary with some regularity to a broad area in the vicinity of Calgary itself where they are near a minimum of 10 feet.

Not all of the Basal Quartz is porous. Figure 5 shows the thicknesses of the porous portion as determined by sample and core studies and electrical logs. Porous sands over 10 feet thick occur in a crescent-shaped area just west of the eastern edge of the sand body, whereas elsewhere they are less than 10 feet thick.

The geologic structure of the top of the Basal Quartz sand is shown as Figure 6. It rises to the east from Bearspaw 22-9 to the North Calgary 27-6 well at a rate of about 83 feet per mile, having slightly less slope than the normal structure of the area (Figure 3). Further east, however, it continues to rise at a rate of only 29 feet per mile to the Kathryn 3-2 well, which contrasts considerably with the normal slope of 68 feet per mile. Thus the gas-bearing sand occupies a somewhat terrace-like position east of the City. The cause for this difference of structure was probably the uneven surface of the Mississippian rocks which governed the depositional thickness and distribution of these basal Blairmore deposits. The relations may be observed in Cross-section A-B (Figure 2) and the situation will be explained further in a description of the underlying Elkton Member.

Producable quantities of gas were found in the Basal Quartz sand in the North Calgary 25-11 well, and gas was obtained in the North Calgary 27-6 well when perforated at 7328 feet opposite the sand. A little black tarry oil was obtained in Kathryn 3-2. These wells are located in the northeast part of the crescent. Southeast of the City, where structural and sand-thickness conditions appear similar to those in the vicinity of the above wells, no significant shows were obtained. It is suggested that porosity and lenticularity in this southeast branch of the Basal Quartz may be such as to have allowed migration of gas further up-dip to meet a stratigraphic trap elsewhere.

The proven area of the Basal Quartz around North Calgary 25-11 and 27-6, as designated by Dr. D.L. Flock in the engineering report, is indicated in Figure 5.

Elkton Member

The Elkton is the "Lower Porous" member of the Turner Valley formation. It contains significant quantities of gas at Jumping Pound, Sarcee, Turner Valley, Sundre, Westward Ho, Harmattan-Elkton, Crossfield, and Calgary. As illustrated by Figure 7, the surface of the Elkton member rises from west to east until it reaches its erosional edge along an irregular line extending in a north-northwest direction. Overlying the Elkton the "Middle Dense" member of the Turner Valley formation wedges out along a somewhat

parallel line 5 to 10 miles west-southwest of the edge of the Elkton.

The Elkton member in the Calgary area consists mostly of very finely to coarsely crystalline light grey to buff dolomite. The coarse crystals are largely dolomitized crinoid segments; the fine crystals form the matrix of the rock. In the lower 30 to 50 feet of the Elkton in Beddington 8-34 and North Calgary 27-6, as shown in the cross-section, Figure 2, there are beds of limestone, largely crinoid fragments, which have not been dolomitized. The Elkton in the Calgary 36-10 well is almost completely undolomitized coarsely crinoidal limestone though a part of it is somewhat chalky because of weathering.

Penner* pointed out that the Elkton can be divided into three submembers. These, together with their thicknesses in Bearspaw 22-9 and Shepard 2-6, are as follows:

	Submember	Bearspaw 22-9	Shepard 2-6
A.	Upper porous	24	60
	Middle dense	30	70
B.	Lower porous	70	53

The limits of the three units are not well defined in the micrologs, sample cuttings, and cores, in the Calgary area. The micrologs show that broadly lenticular and dense portions occur in the Elkton at various horizons. However, it would appear that in general the submembers are present and that the two upper units thicken and the lowest thins southward. Porosity occurs as vugs, intercrystalline spaces and some vertical to horizontal fractures. The vugs vary from pin-point size up to 1 inch in diameter, most of them being 3/8-inch or smaller, having somewhat the shape of the crinoid fragments that were dissolved in the process of their formation. The lower porous submember is consistently the more porous, averaging 10% porosity and, in a few samples, reaching a maximum of 21%. The middle "dense" submember is only less porous than the other two, averaging 6% porosity. The upper porous submember shows considerable variation in porosity in the micrologs and averaged 8.5% in one well and 6.2% in another.

As illustrated by the cross-section (Figure 2) the Elkton member is cut off at its contact with the pre-Basal Quartz erosional

*Penner, D.G., 1957, "The Elkton Member", Jour. Alberta Soc. Petrol. Geol., Vol. 5, No. 5, pp. 101-104.

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surface. By plotting the figure obtained by measuring in each well log the distance from a certain recognizable horizon in the lower Blairmore down to the top of the Mississippian strata, a map of the configuration of the eroded surface of the Mississippian rocks before Basal Quartz deposition (Figure 8) was constructed. On it is shown the pattern of Mississippian formations exposed at that time.

Assuming that the 225-foot contour represents about the general ground level at the time, the map shows a hill about 90 feet high, with summit in the vicinity of North Calgary 27-6, elongate in a north-south direction, and flanked on the east by a valley about 55 feet deep. The hill consists almost entirely of the Elkton member. To the west the eastern wedge edge of the overlying Middle Dense member of the Turner Valley formation reaches to the foot of the hill and to the east the underlying Shunda formation was exposed in the valley. As was suggested under the description of the Basal Quartz, this is the topography that influenced the lithologic characters and the pattern of deposition of the Basal Quartz and the other lower Blairmore deposits until all unevennesses were erased by being covered up.

The structural map of the top of the Elkton in the Calgary area (Figure 9) shows about the normal rate of structural rise west of the Fifth Meridian as shown by the base of the Exshaw (Figure 3). East of the Meridian, however, the effect of erosional truncation of the Elkton is to widen the spacing between contours. In fact the introduction of the -3750 contour makes it possible to show that the surface rises from the west to the top of the hill at 3745 feet below sea level at North Calgary 27-6, and from there descends slightly to the east with the wedge edge only 3755 feet below sea level.

Figure 10 shows the thickness of the Elkton member in the Calgary area. Penner (op. cit. p. 101) illustrated how the regional thickness increases southeastward in this region. In the Calgary area a maximum of 150 to 183 feet was reached along the ridge edge of the uneroded formation which extends in a north to northwesterly direction under the eastern part of the City. Thereafter to the northeast and east the thickness decreases sharply to the wedge edge of the eroded rock unit.

The aggregate thickness of porous portions of the Elkton, as estimated from the micrologs, is indicated in Figure 11. The amount of porous rock decreases from a maximum of 144 feet thickness in Balzac 16-18 to 0 at the wedge edge. Although Calgary 36-10 penetrated 65 feet of Elkton, none of the rock appears porous due to the fact that the Elkton consists of dense limestone instead of porous

dolomite at this place. From observation elsewhere in Alberta of similar occurrences of isolated limestone patches along the eastern edge of an eroded dolomitized formation this occurrence may similarly indicate that the Elkton strata penetrated by Calgary 36-10 may be in a block of limestone which was isolated by erosion and thus prevented from being dolomitized by circulating ground waters.

Commercial quantities of gas, without water, were encountered at various depths in the Elkton in the North Calgary 27-6 well, which is situated near the top of the pre-Basal Quartz ridge. Calgary 27-11, situated in a similar position, where the top of the Elkton is only 18 feet lower in elevation, encountered gas in small quantities only in tests at various depths in the Elkton, and obtained considerable quantities of salt water in each test. Calgary 36-10 penetrated impermeable rock in the Elkton, but Chestermere 18-11, encountering the Elkton top 80 feet higher than in the North Calgary 27-6 well, obtained salt water in the formation. Evidently there is a permeability barrier between the north well and the other wells to the south, as was suggested by Westcoast in its October 1957 Supplement to their Application before the Oil and Gas Conservation Board, Section H-6, p.4. Such a barrier could be an east-west valley cutting through the ridge and filled with basal Blairmore non-porous sandy clays.

The proven area of the Elkton around North Calgary 27-6, as designated by Dr. D.L. Flock, in the engineering report, is shown in Figure 11.

Crossfield Member

The Crossfield member is in the middle of the Wabamun group, which is the dolomite formerly known as the D1 oil-producing zone of Alberta. The top of the Wabamun occurs about 250 feet above the Crossfield. These strata overlying the Crossfield consist mostly of buff dense dolomite but there is more or less dense buff to brown anhydrite interbedded and mottled with the dolomite, in some places exceeding 50% of the rock. In the 50 feet of strata directly over the Crossfield the anhydrite content is low, never being over 10%.

The Crossfield member in the Calgary region may be divided into three zones, as follows:

A. Upper grey to brown dolomite with poor porosity.

B. Middle brown porous dolomite.

C. Lower grey thin-bedded dolomite with poor porosity.

The upper grey to brown dolomite is very finely crystalline having a sugary appearance. The porosity, due to scattered to numerous pin-point vugs, ranges from 1 to 3%.

Zone B is the main gas-bearing zone of the Crossfield in the Calgary area. The dolomite is buff to dark brown, frequently having a resinous appearance. The rock is quite firm but is brittle and breaks with a characteristic horizontal sliver-like fracture and a minor vertical fracture perpendicular to the sliver. Pores are in the form of scattered to numerous pin-point vugs, scattered vugs up to 1/2 inch in diameter, and a few vugs up to 1 inch in diameter. Probably some of the porosity can be attributed to the incipient fractures. Some of the vugs and an occasional fracture have been more or less filled with white secondary crystalline anhydrite and some sulphur. A large percentage of the vugs have thin coatings of tar. The porosity averages 4.4%. The zone varies from 34 to 84 feet in thickness.

The C zone consists predominantly of light grey to buff very finely crystalline dolomite but there are occasional beds similar to those in Zone B. Some portions show bedding 1/2 to 1 inch in thickness, a characteristic which helps to identify the zone in the cores. Porosity is in the form of scattered to numerous pin-point vugs, though some of it in the thin bedded dolomite appears to be due to horizontal partings rather than pores in the rock. Porosities average 2 to 3.3% in the various wells though occasional tests run to as much as 7%. The zone varies from 0 to 38 feet in thickness.

The rock underlying the C zone consists of light grey to brown argillaceous dolomite having thin shaly laminae. Mottling by white anhydrite begins here and increases downward.

The geologic structure of the top of the Crossfield (Figure 12) is similar to the regional structure, being almost a plane surface rising eastward at a rate of 93 feet per mile to the Beddington well and thereafter decreasing in slope to 70 feet per mile. The gas-water contact, estimated by Dr. Flock to be 5230 feet below sea level, intersects the top of the Crossfield close to the line of the Fifth Meridian.

A map of the thickness of the Crossfield (Figure 13) shows it to thin eastward from 145 feet at Beddington 8-34 and A.N.D. 1 to 107 feet at North Calgary 25-11 and 109 feet at Chestermere 18-11. Northeastward from North Calgary 25-11 it thickens to 140 feet at Kathryn 3-2, and southeastward from Chestermere 18-11 it thins to 56 feet at Shepard 10-15.

Core analyses show porosities of the Crossfield varying from practically 0 up to about 9%, with a few showing as much as 14%. The average is about 4.3%. A map of the porosity-feet of the Crossfield above the gas-water contact at 5230 feet below sea level is shown in Figure 14. The figures on porosity-feet at each well are furnished as part of the core analysis and are obtained by multiplying the footage length represented by each tested core chip by the percent porosity of that core chip and adding these together for the whole Crossfield core. Where there were no core data available, estimates were made from the sample cuttings. The map shows a north-south elongate area of maximum values in the vicinities of North Calgary 25-11 and Calgary 36-10. Values west of this were decreased by the water filling the lower part of the Crossfield and those to the east are low because of thinness of the Crossfield to the southeast and lack of porosity in the thick Crossfield to the Northeast.

January 7, 1958. "L.E. WORKMAN" P. Eng.

FIGURE 1. GEOLOGIC SUCCESSION IN CALGARY AREA

SYSTEM	FORMATION	MEMBER	THICK	DEPTH	GRAPHIC	DESCRIPTION
PALEOCENE	PASKAPOO		1000	1000		SANDSTONE, SHALE
UP. CRET.	EDMONTON BEARPAW BELLY RIVER		5150			SANDSTONE, SHALE, COAL
UP. CRET.	LEA PARK			6150		BLACK SHALE
UP. CRET.	COLORADO	FISH SCALE SAND	50	6200		SHALY SANDSTONE
LOWER CRETACEOUS	COLORADO		50	6250		BLACK SHALE
LOWER CRETACEOUS	VIKING		125	6375		SANDSTONE
LOWER CRETACEOUS	JOLI FOU		40	6415		BLACK SHALE
LOWER CRETACEOUS	BLAIRMORE		750	7165		SANDSTONE AND SHALE
LOWER CRETACEOUS	BLAIRMORE: ELLERSLIE		105	7270		QUARTZ SAND AND CLAY
LOWER CRETACEOUS	BLAIRMORE: ELLERSLIE	BASAL QUARTZ	20	7290		QUARTZ SAND
MISSISSIPPIAN	TURNER VALLEY	MIDDLE DENSE	30	7320		DOLOMITE
MISSISSIPPIAN	TURNER VALLEY	ELKTON	150	7470		DOLOMITE, SOME LIMESTONE
MISSISSIPPIAN	SHUNDA		220	7690		SILTY DOLOMITE SHALY LIMESTONE
MISSISSIPPIAN	PEKISKO		275	7965		LIMESTONE
MISSISSIPPIAN	BANFF		430	8395		SHALY LIMESTONE AND SHALE
MISSISSIPPIAN	EXSHAW		20	8415		BLACK SHALE
DEVONIAN	WABAMUN		250	8765		DOLOMITE AND ANHYDRITE
DEVONIAN	WABAMUN	CROSSFIELD	115	8980		DOLOMITE

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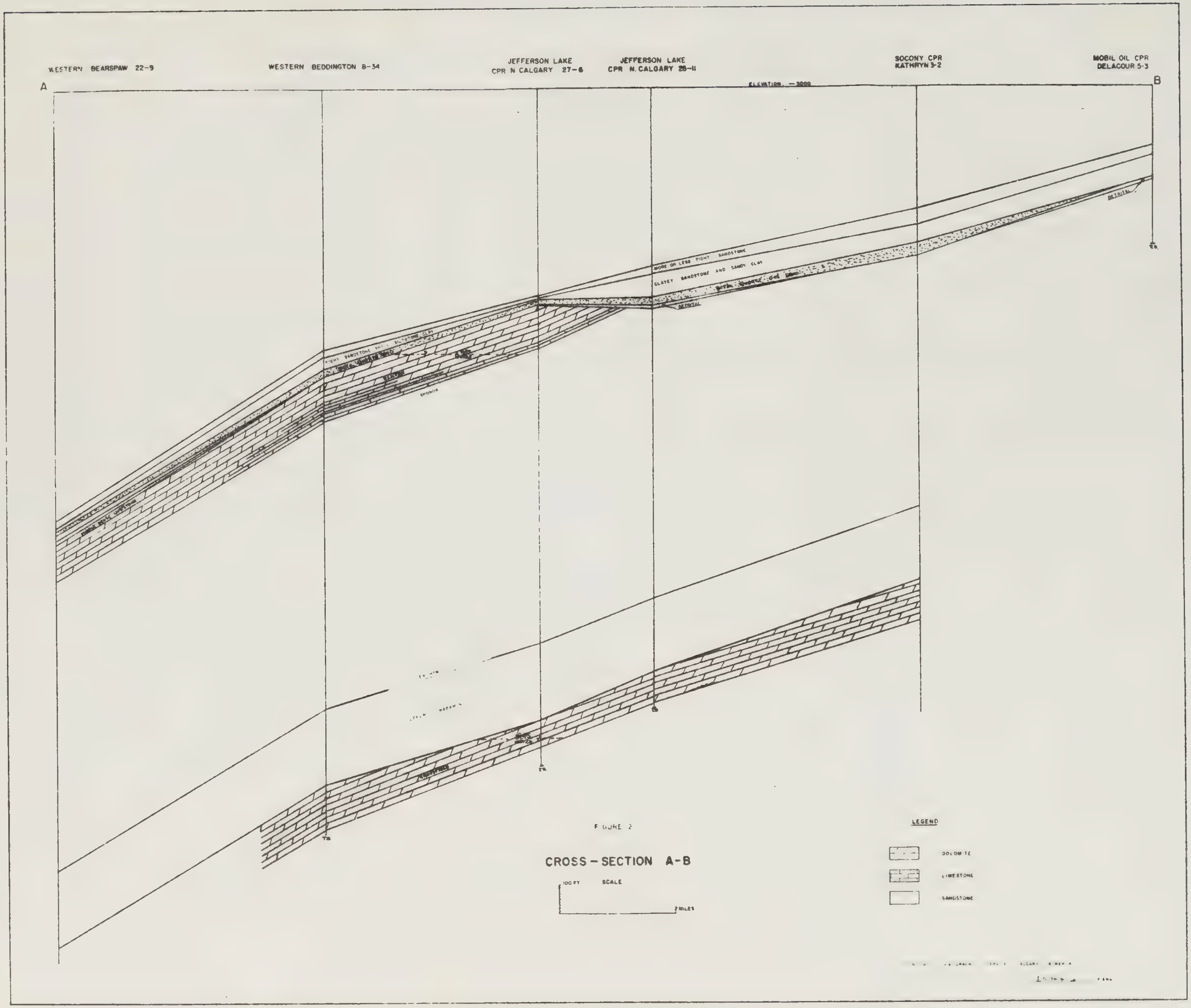


FIGURE 2

CROSS-SECTION A-B

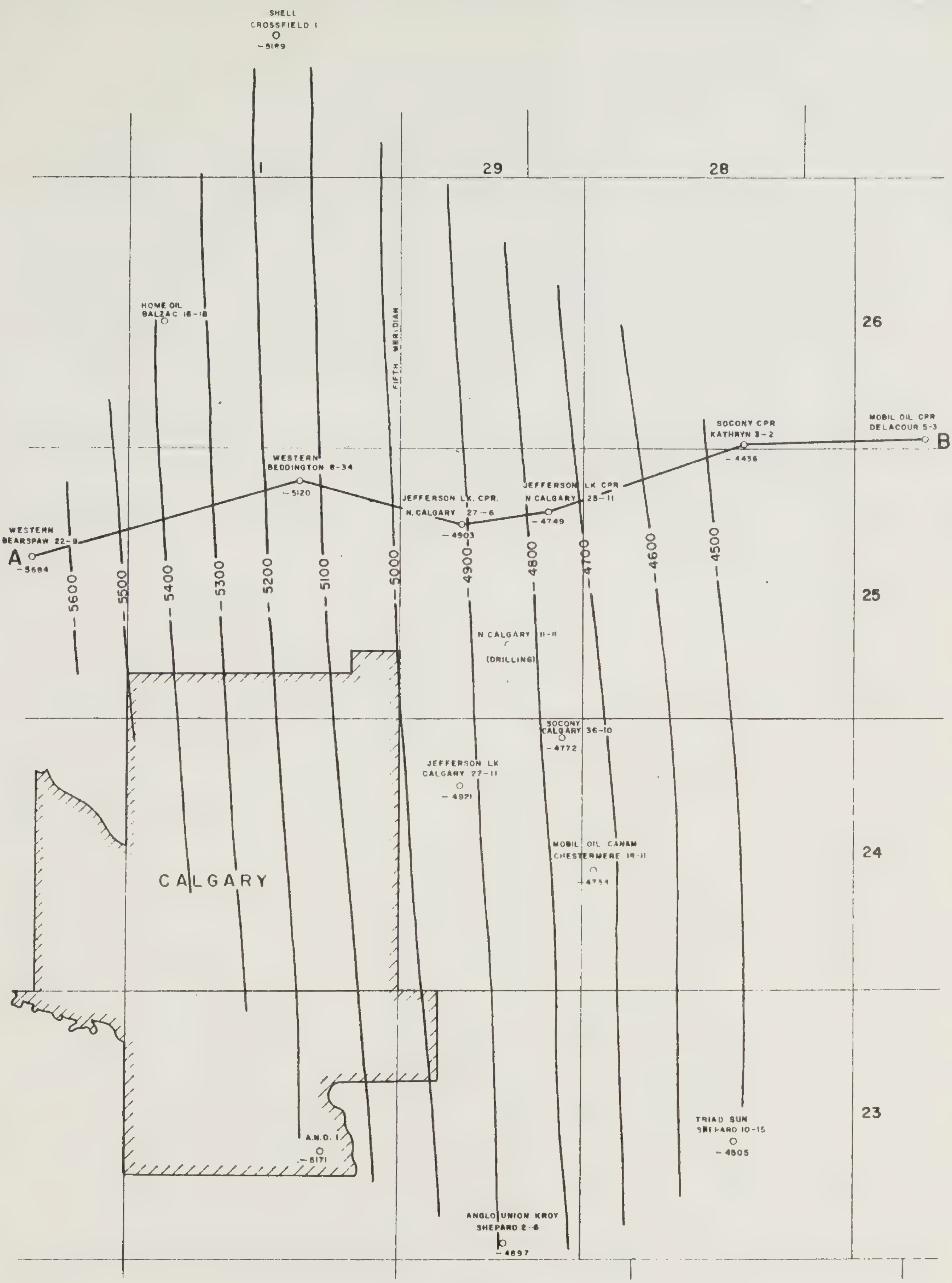


FIGURE 3

GEOLOGIC STRUCTURE OF BASE OF EXSHAW SHALE

ELEVATIONS IN FEET BELOW SEA LEVEL

0 1 2 3 4 5 6 miles

JANUARY 7, 1958

L.E. Workman P ENG

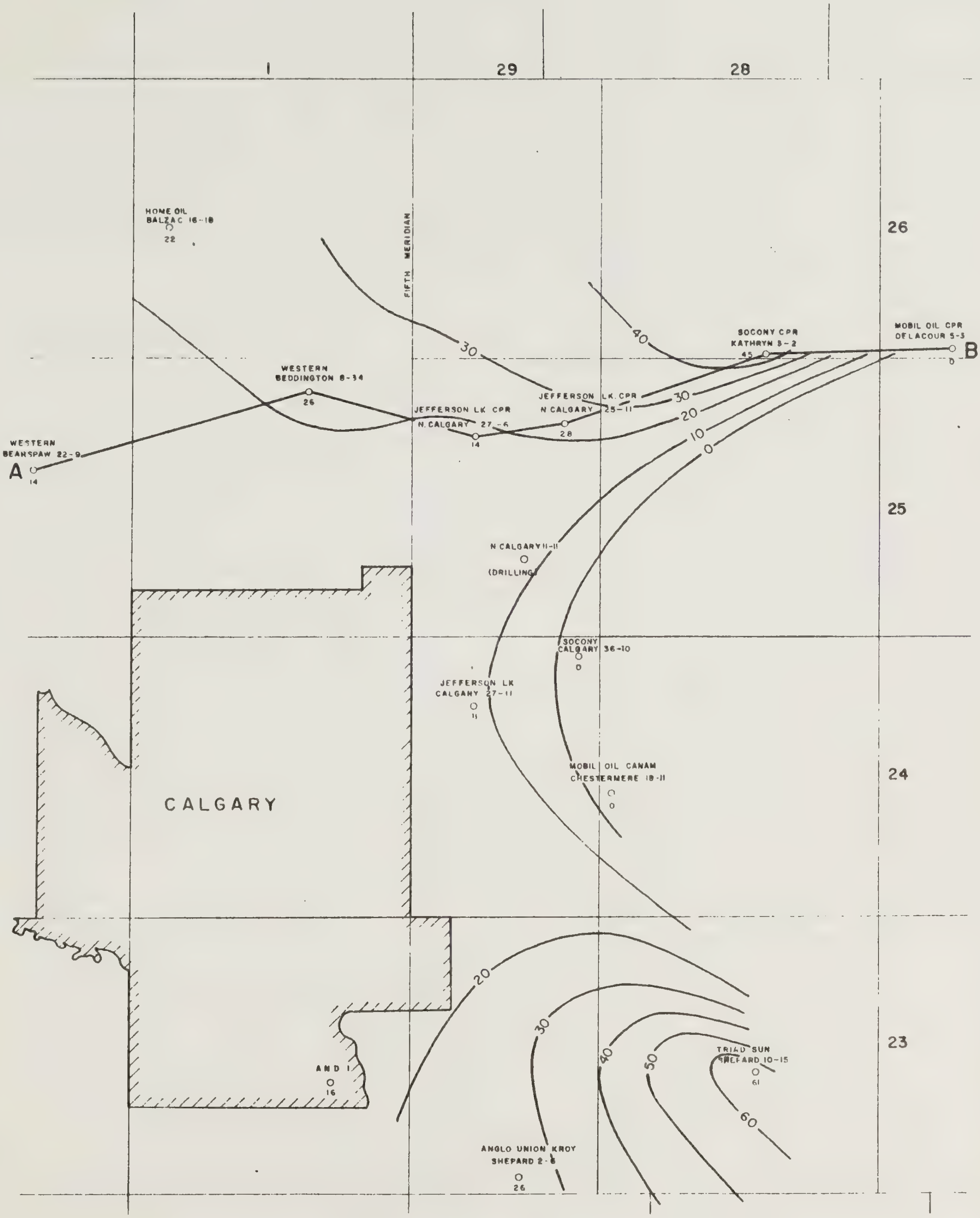


FIGURE 4

BASAL QUARTZ THICKNESS

ISOPACH INTERVAL 10 FEET

0 1 2 3 4 5 6 miles

JANUARY 7, 1958

L.E. Workman P. ENG

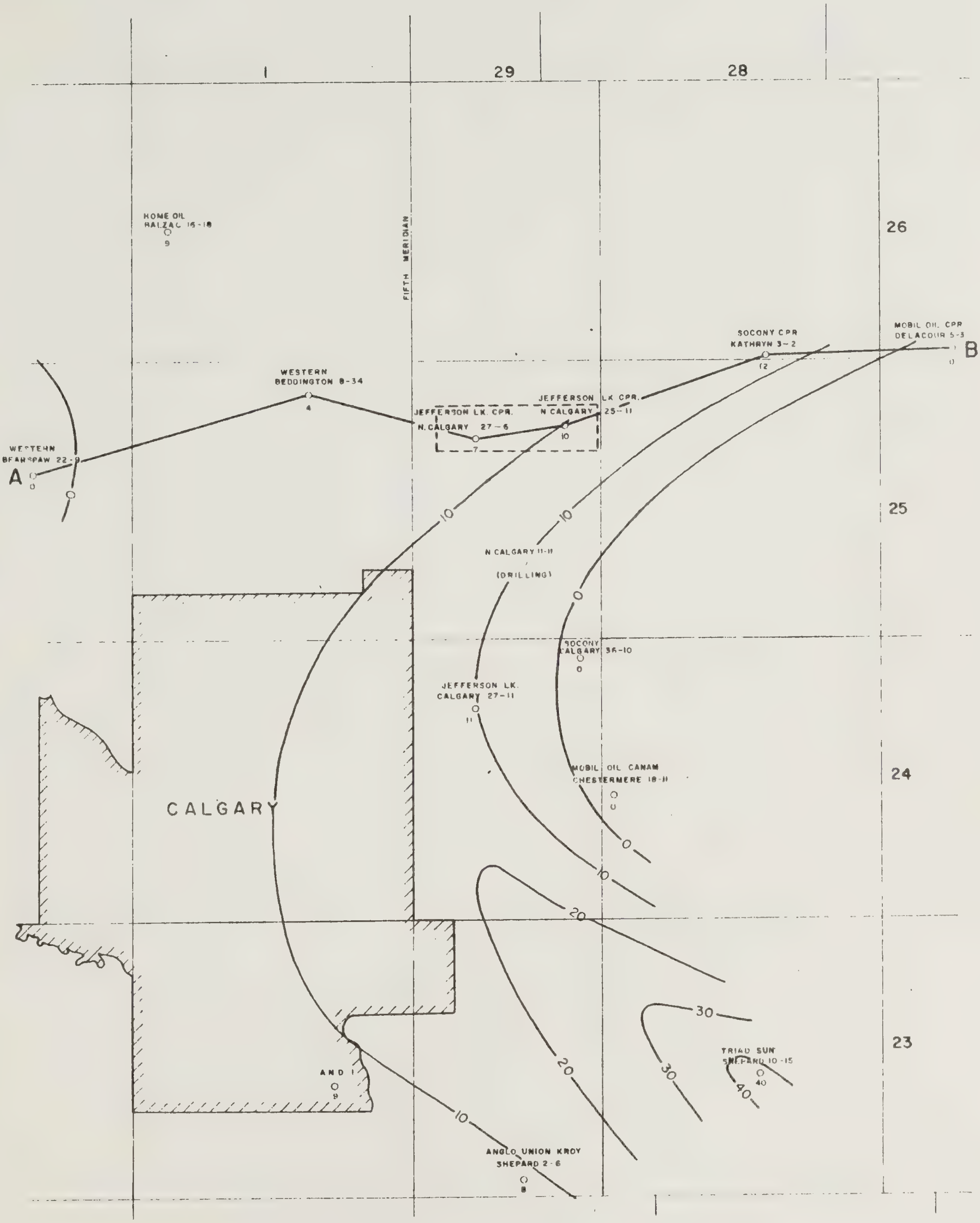


FIGURE 5

THICKNESS OF POROUS PORTION OF BASAL QUARTZ SAND

PROVEN AREA

0 1 2 3 4 5 6 miles

JANUARY 7, 1958

L.E. Workman, ENG

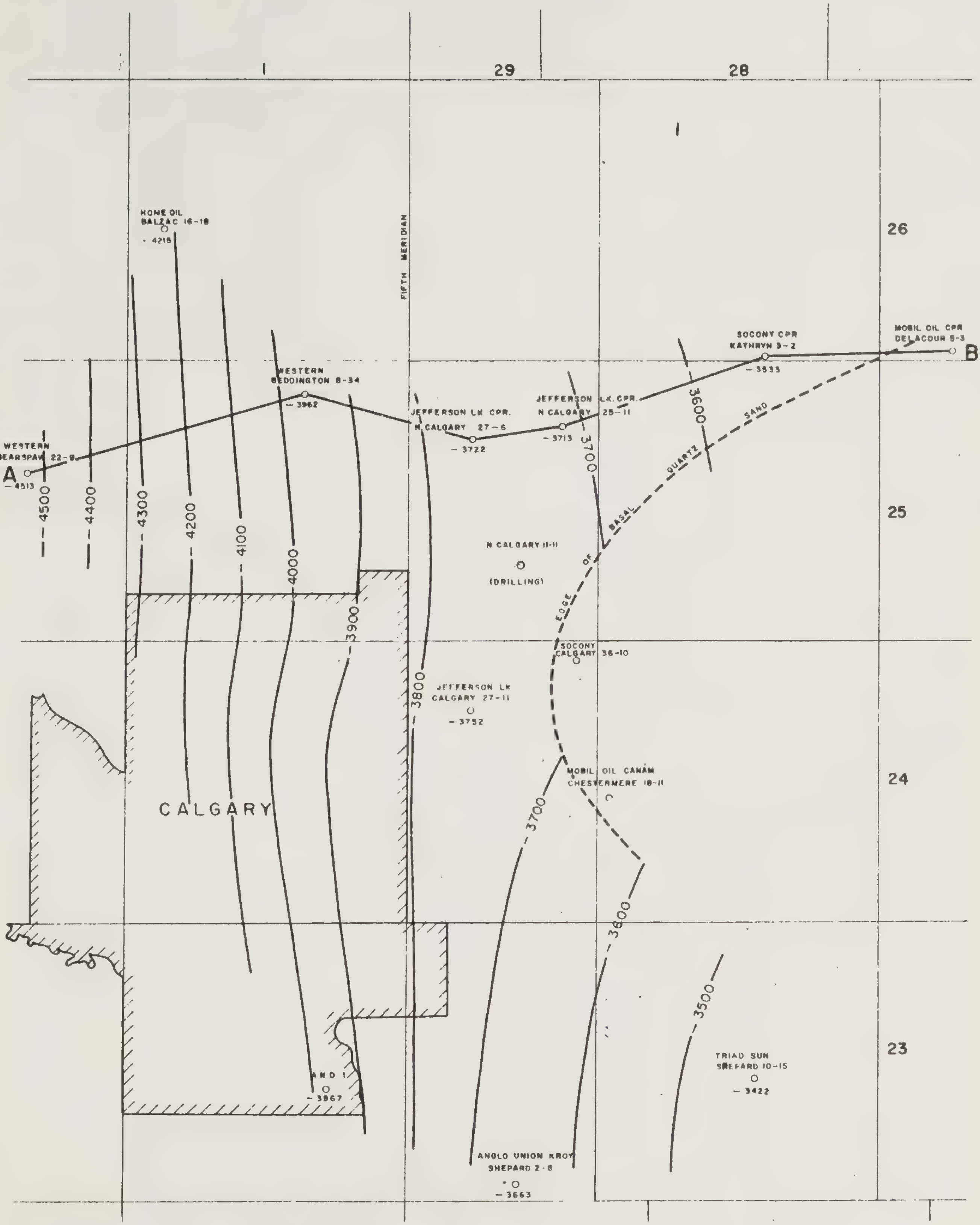


FIGURE 6

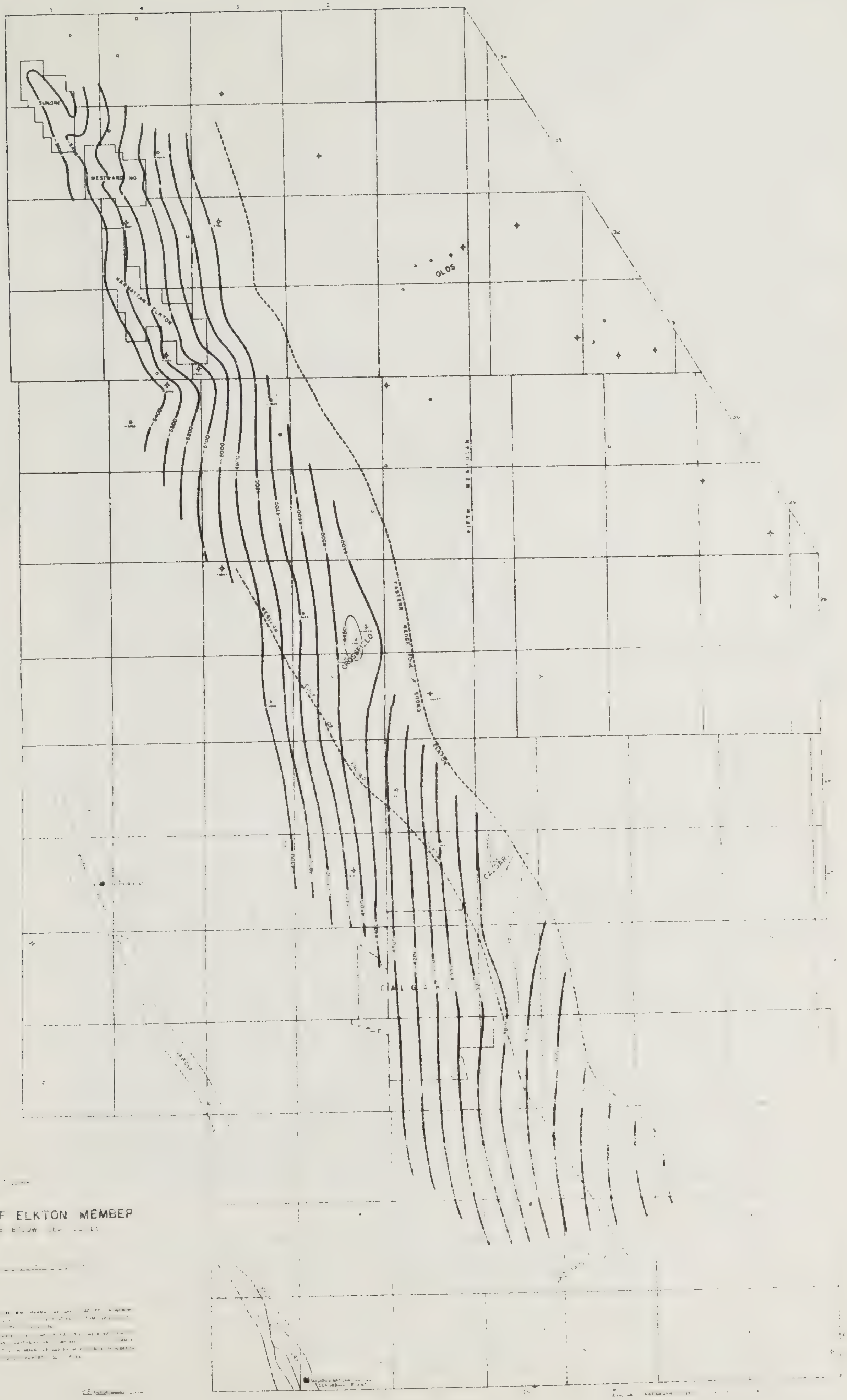
STRUCTURE OF TOP OF BASAL QUARTZ SAND

ELEVATIONS IN FEET BELOW SEA LEVEL

0 1 2 3 4 5 6 miles

JANUARY 7, 1958

L.E. Workman P.ENG



SURFACE OF ELKTON MEMBER

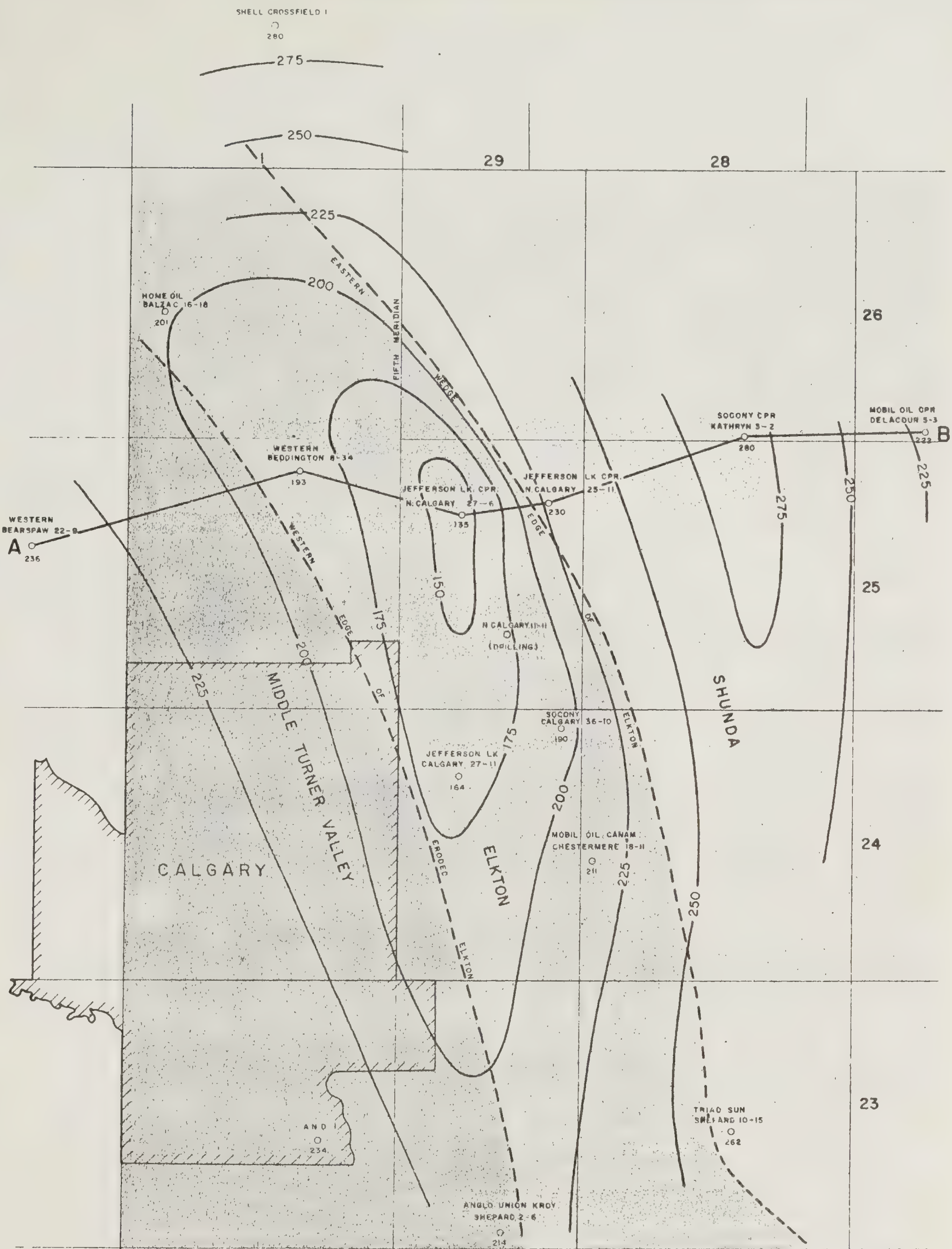


FIGURE 8

AREAL GEOLOGY AND GENERAL CONFIGURATION OF SURFACE OF THE MISSISSIPPIAN STRATA BEFORE BASAL QUARTZ DEPOSITION

FIGURES SHOW NUMBER OF FEET BELOW CERTAIN HORIZON IN BLAIRMORE

0 1 2 3 4 5 6 miles

JANUARY 7, 1958

P. ENG

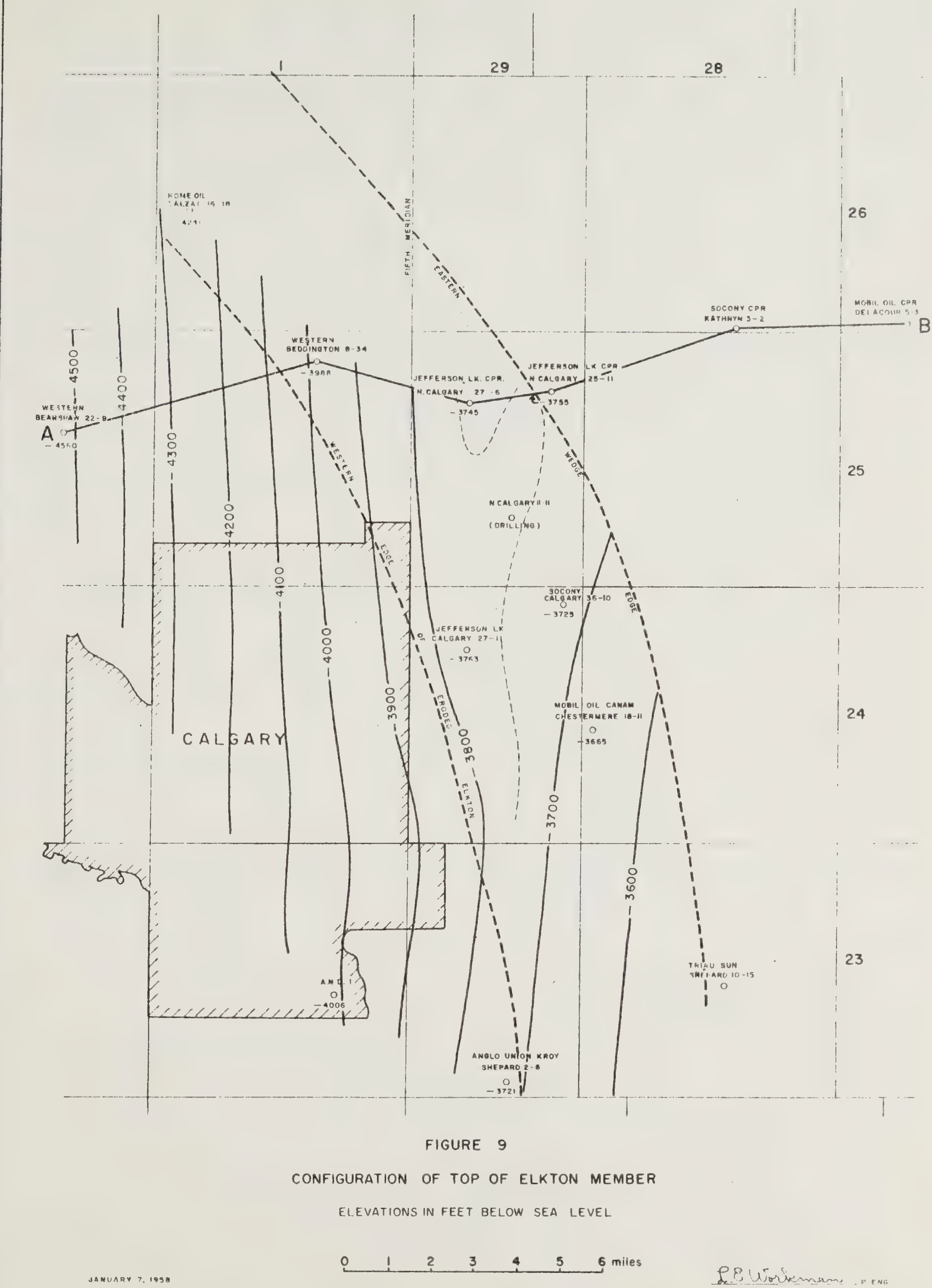


FIGURE 9

CONFIGURATION OF TOP OF ELKTON MEMBER

ELEVATIONS IN FEET BELOW SEA LEVEL

JANUARY 7, 1958

L.E. Workman, P. ENG

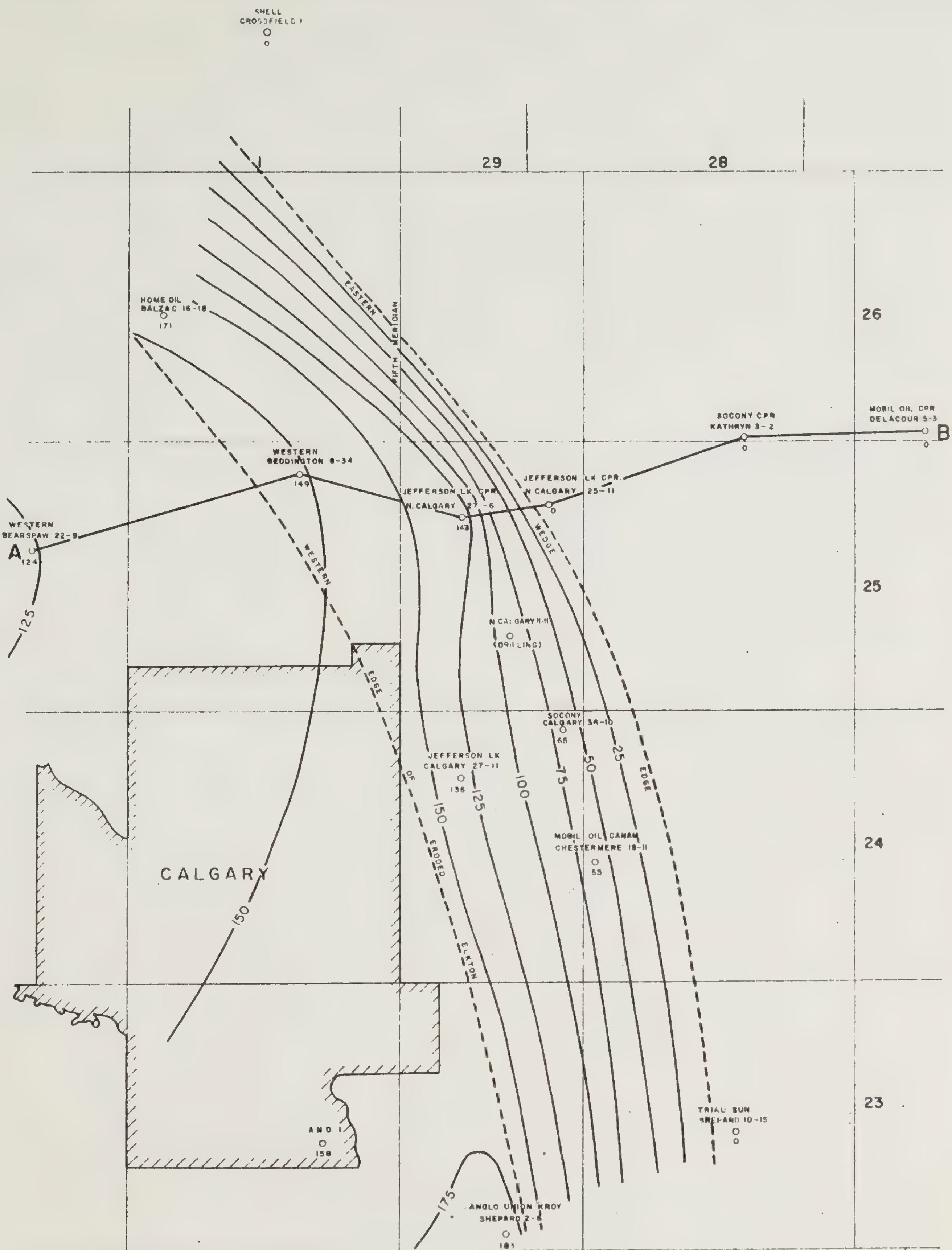


FIGURE 10

THICKNESS OF ELKTON MEMBER

ISOPACH INTERVAL 25 FEET

JANUARY 7, 1958

L.E. Workman P.ENG

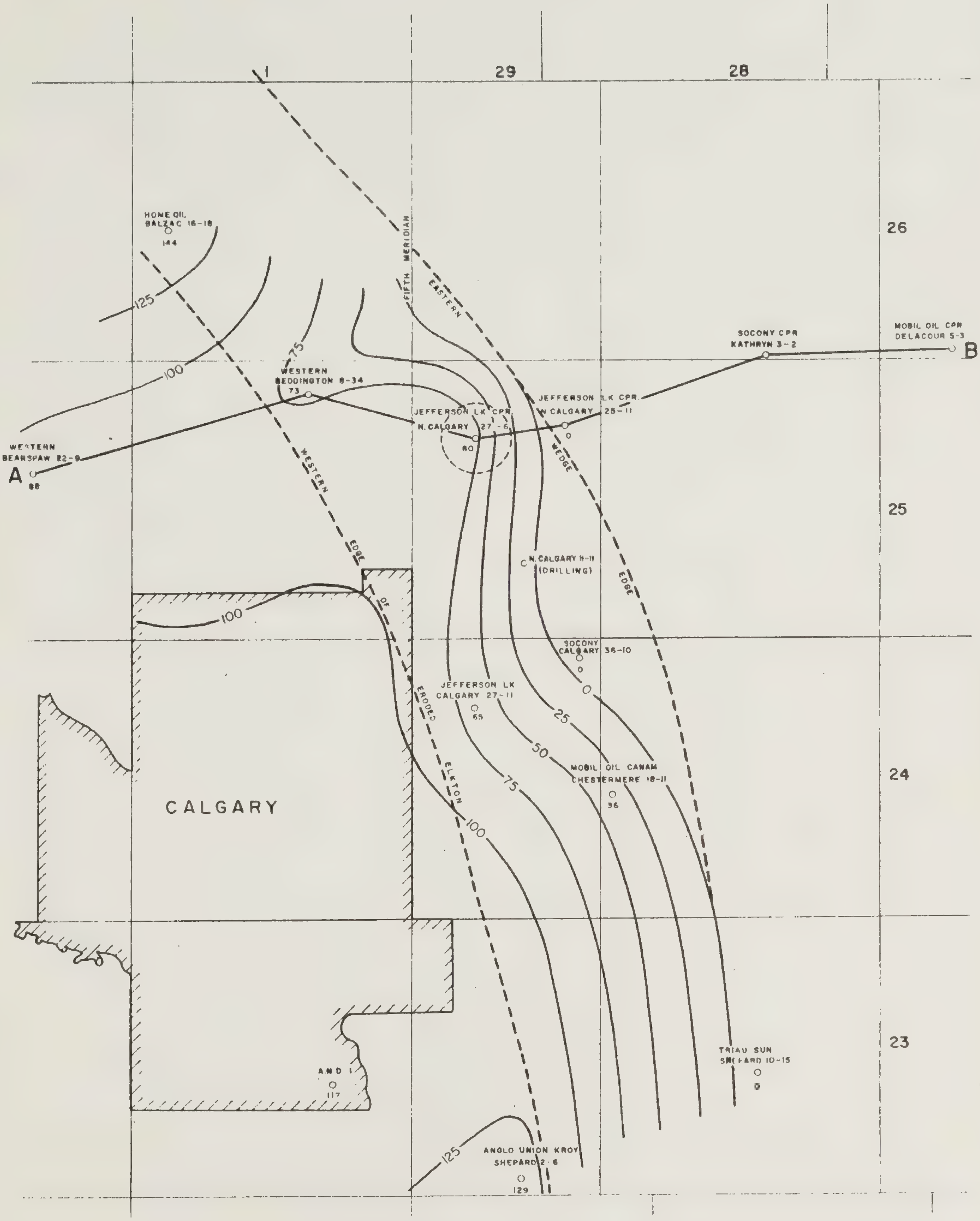


FIGURE 11

AGGREGATE THICKNESS IN FEET OF POROUS PORTIONS OF ELKTON MEMBER

AS COMPUTED FROM MICRO-LOGS

PROVEN AREA

0 1 2 3 4 5 6 miles

JANUARY 7, 1958

L.E. Workman P. ENG

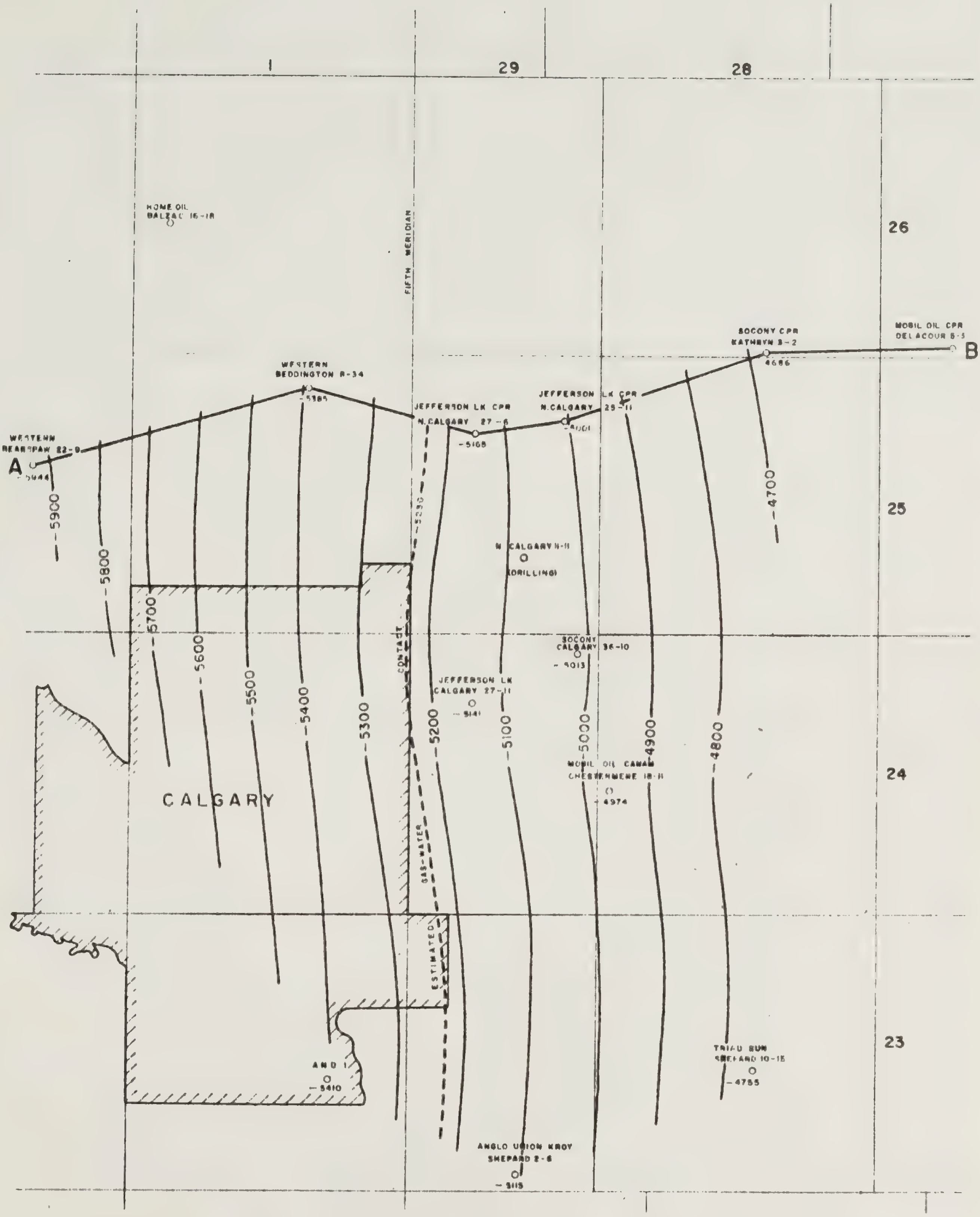


FIGURE. 12

GEOLOGIC STRUCTURE OF TOP OF CROSSFIELD MEMBER

ELEVATIONS IN FEET BELOW SEA LEVEL

0 1 2 3 4 5 6 miles

JANUARY 7, 1958

P.ENG

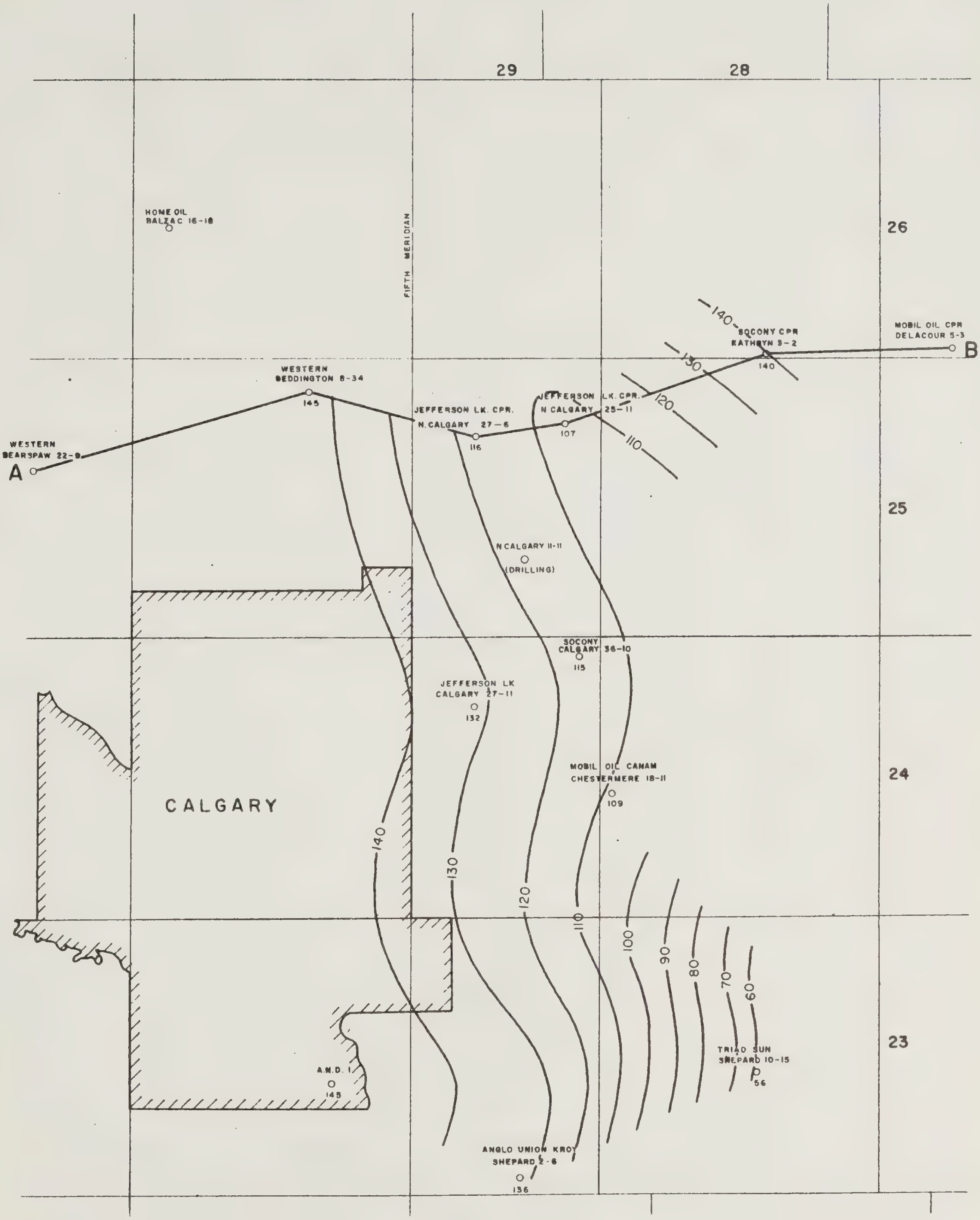


FIGURE 13

THICKNESS OF CROSSFIELD MEMBER

ISOPACH INTERVAL 10 FEET

0 1 2 3 4 5 6 miles

JANUARY 7, 1958

L.E. Workman P ENG

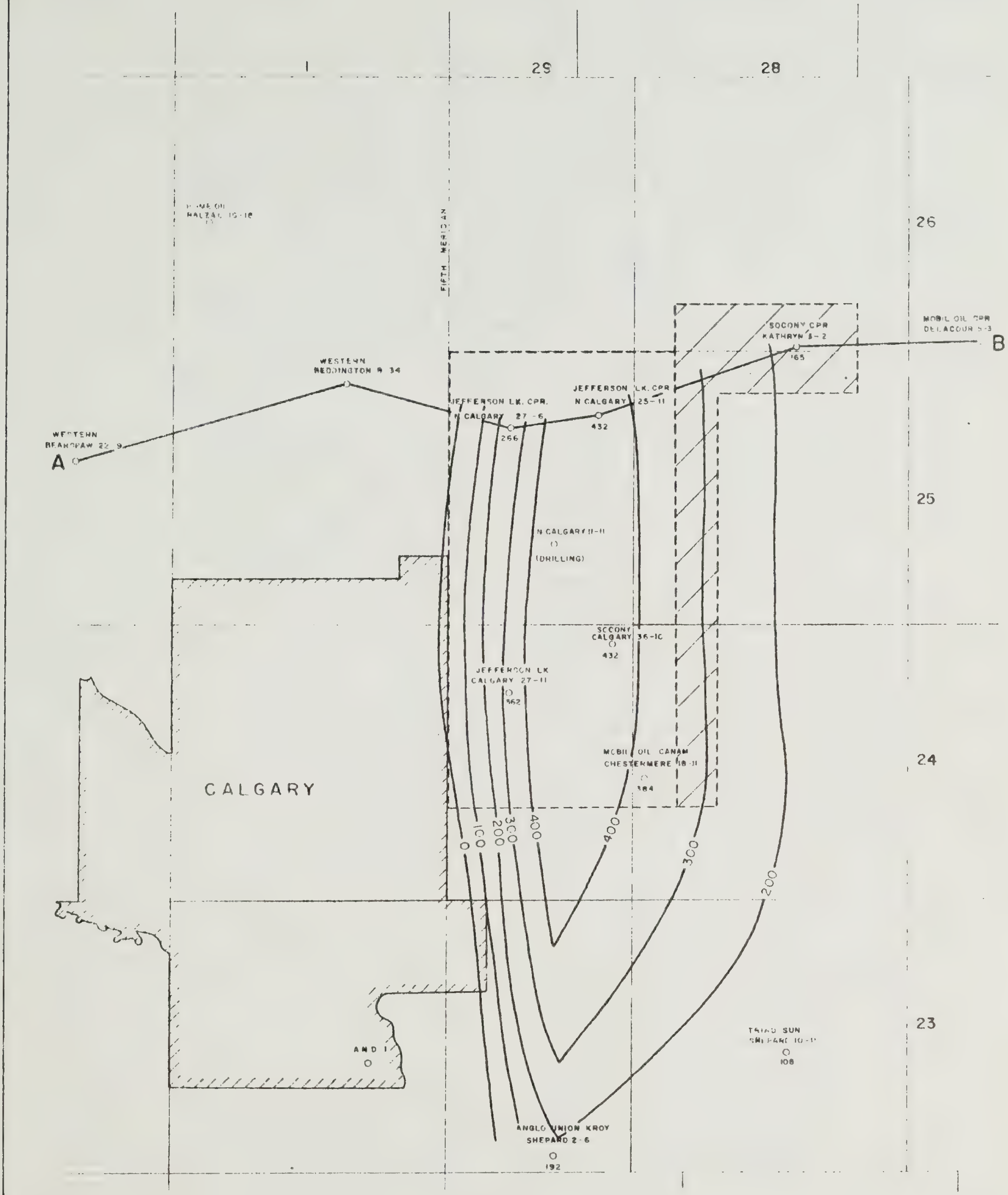


FIGURE 14

CROSSFIELD POROSITY – FEET

ABOVE GAS-WATER CONTACT AT 5230 FEET BELOW SEA LEVEL

PROVEN AREA PROBABLE AREA

0 1 2 3 4 5 6 miles

JANUARY 7, 1958

P. ENG

BIOGRAPHICAL SKETCH

DONALD L. FLOCK

D.L. Flock holds B. Sc. and M. Sc. degrees in Petroleum Engineering from the University of Oklahoma, and a Ph. D. degree in Petroleum Engineering from A and M College of Texas. He has been employed as a research engineer in charge of a number of production engineering projects with the Cities Service Research and Development Company in Tulsa, Oklahoma. Dr. Flock is now serving as an Associate Professor of Petroleum Engineering at the University of Alberta, Edmonton, Alberta.

REPORT ON
GAS RESERVES AND DELIVERABILITY
FORECAST

CALGARY FIELD

January 1958

by

DONALD L. FLOCK, P. ENG.

Department of Chemical and Petroleum Engineering
University of Alberta

EDMONTON, ALBERTA

PART "B"

TABLE OF CONTENTS

TABLES

CALGARY GAS FIELD

SUMMARY

The present gas reserves of the Calgary Field and a thirty-year deliverability forecast for the Crossfield zone existing in this field are presented in this report.

There are three productive gas reservoirs in the Calgary Field; the Basal Quartz member (Cretaceous), the Elkton member (Mississippian) and the Crossfield member (Devonian). The reserve estimates are based on information from essentially six completed gas wells within the limits of the field. The total proven areas selected for each of the three reservoirs are indicated on isopacheous maps presented in the geological section accompanying this report.

The reserves estimated in this study show a gross marketable gas reserve of 16.84 M^3CF* for the Basal Quartz, 32.85 M^3CF for the Elkton and 302 M^3CF for the Crossfield member of the Calgary Field.

The deliverability and development schedule for the Crossfield zone indicates that approximately 5.90 M^3CF of gas annually can be delivered from this reservoir for twenty-seven years (commencing1961), resulting in a 53.1% depletion of the total gas in place.

BASAL QUARTZ RESERVOIR

The Basal Quartz sand reservoir was found productive in two wells at an average depth of 7200 feet. The east, south and west boundaries of this reservoir seem to be limited by some apparent discontinuity in the sand. The northern limit is undetermined at this time.

The average porosity of the Basal Quartz was estimated from data available on other Basal Quartz horizons outside the Calgary Field. The reservoir temperature was selected taking into consideration data on the underlying Elkton member. Drill stem test results on this sand provided the data for the estimation of reservoir pressure. Gas compressibility and specific gravity were calculated directly from a gas analysis shown in Table IV. A summary of all gas analysis calculations is presented in Table V.

The recovery factor applied to the initial gas in place was

*All gas volumes at 14.4 psia and 60°F

estimated from data on similar reservoirs as presented in the "Petroleum and Natural Gas Conservation Board Document on Natural Gas Reserves of the Province of Alberta, January 31, 1957". This factor accounts for the gas remaining in the reservoir at abandonment. The essential results for estimated gas reserves of the Basal Quartz are tabulated in Table 1.

It was requested for this report that the Basal Quartz zone be considered as a possible storage reservoir for natural gas. In the analysis of a reservoir for storage possibilities, consideration must be given to geologic structural characteristics, upstructure movement of encroaching fluids during withdrawal, formation of fluid blocks insitu during pressure decline, reservoir shrinkage which would result from fluid encroachment. The analysis of such factors from such a limited amount of data is almost impossible. Although geologic results obtained on this zone indicate that the Basal Quartz might be a suitable reservoir for storage, it is suggested that such a recommendation be deferred until the field is more completely developed.

ELKTON RESERVOIR

One well, Jefferson Lake C.P.R. Calgary No. 27-6, penetrates productive Elkton in the Calgary Field at an average depth of 7400 feet. The total proven area selected for reserve estimates is designated by a three-quarter mile radius surrounding the well. The Elkton was encountered in two wells to the south, Jefferson Lake C.P.R. Calgary No. 27 - 11 and Mobil Oil Chestermere No. 18 - 11, but drillstem tests in both wells recovered water. Socony Calgary No. 36 - 10 encountered Elkton but was found to be tight and non-productive. Eroded edges of the Elkton define the extreme possible East and West boundaries of the field.

The Western Beddington No. 8 - 34 well to the west and downdip gave slight gas indications, but was full of water. It is not known whether the Elkton in this well is related to that found in Jefferson Lake C.P.R. Calgary No. 27 - 6 with a gas-water contact between them.

From the core analysis on the Elkton the porosity and connate water were estimated to be 7.25%, and 25% respectively. The reservoir temperature was estimated from drillstem test results. The reservoir pressure is an average of both the measured and calculated bottom hole pressures from a back pressure test. The compressibility and specific gravity of the gas were calculated from gas analysis. The results are summarized in Table V. The

gas will have to be processed because of its hydrogen sulfide content. A total shrinkage of 14% was selected based upon information in Exhibit A - 5 of the Westcoast Transmission Company Limited application. The average net thickness of the Elkton was estimated from micrologs available.

The volumetric estimate of gas initially in place was found to be 45 M^3CF at 14.4 psia and 60°F. Applying an 85% recovery factor and a 14% shrinkage and fuel loss, the gross marketable reserves were found to be 32.85 M^3CF. Results are summarized in Table II.

CROSSFIELD RESERVOIR

The Crossfield reservoir, at an average depth of 8500 ft., is a Devonian formation dipping to the west and contains a sour gas with an unusually high (32.17%) hydrogen sulfide. From a study of core analysis and drillstem tests on Jefferson Lake C.P.R. Calgary No. 27 - 11 a water contact on the down-dip side was found to exist at a depth of 5230 feet subsea. Core analysis data were available from five wells penetrating the Crossfield member. An arithmetic average porosity of 4.36% was established from the analysis. The net productive intervals above the water contact were selected from micrologs. The connate water is an estimated figure. The compressibility factor and specific gravity of the gas were calculated from gas analysis. The results are tabulated in Table V. The reservoir pressure is an average figure selected from calculations made on back pressure tests in a number of wells (See Table V111).

The reserve estimate is based on proven and probable acreage as indicated on an isopacheous map in the geological section accompanying this report. From a study of the surface and structural nature of the Crossfield member, the area between the northern wells No. 27 - 6 and 25 - 11 and the southern wells No. 36 - 10 and No. 27 - 11 was selected as proven. West and East boundaries were selected as the 5th meridian and a line six sections east of the 5th meridian respectively. A back pressure test on the Crossfield present in Socony Kathryn No. 3 - 2 gave an A.O.F. of 2,100 MCF/D. In view of the high cost of drilling and completing such wells it was felt that the area surrounding this well plus a strip one section wide on the east side of the proven area must be considered as only probable productive Crossfield.

With the above considerations in mind, the total marketable gas reserve of the Crossfield was found to be 302 M^3CF with an additional 103 M^3CF probable. Reserve calculations and reservoir data are tabulated in Table III.

DELIVERABILITY AND DEVELOPMENT SCHEDULE
FOR THE CROSSFIELD RESERVOIR
CALGARY FIELD

The performance of a particular gas reservoir depends upon the physical conditions of the formation, the properties of the flowing phase, the extent of the drainage area of each well and the pressure gradient within the drainage area. The performance of an individual gas well is best demonstrated by a back pressure test. Tests of this nature were performed on four wells in the proven Crossfield reservoir and the results are tabulated in Table VI. Consideration was given to the stabilization time for each run when selecting the best straight line for the data. From these results an average open flow of 16.2 M^2CF/D was found for the Crossfield reservoir. Calculations were performed on Socony Calgary No. 36 - 10 back pressure tests before and after acidization with results shown in Table VIII and Figure 2. In column (1) the bottom hole pressures were observed directly with a pressure bomb on bottom. The pressures in column (2) were calculated following a procedure outlined by A. L. Vitter in the publication "Back Pressure Tests on Gas Condensate Wells", Drilling and Production Practice, 1942. In column (3) the pressures tabulated were found by the general procedure outlined in the manual of the Texas Railroad Commission "Back Pressure Test for Natural Gas Wells". Examination of Figure 2 indicates that many of the straight lines had to be corrected to a slope equal to or less than 1.0. The slope established by calculations on No. 36 - 10 after the acid treatment (Vitter's formula), was selected for the correction of any irregular data. A value of 28,000 MCF/D was selected as the absolute open flow for this well. Similar results on other Crossfield wells, with appropriate corrections applied, are shown in Figures 3 and 4. The absolute open flow of Chestermere Lake No. 18 - 11 was found to be 5,500 MCF/D, which is about one-fifth of that found for the nearby No. 36 - 10 well. This well is considered near the edge of the commercially proven area of the Crossfield zone. A back pressure test run on Jefferson Lake C.P.R. Calgary No. 27 - 11 calculated out to a 7,400 MCF/D absolute open flow. This well was initially perforated throughout the entire interval and produced water along with the gas. A cement plug was run over the lower interval, but subsequent tests still produced an appreciable amount of water. The producing gas-water ratio was taken into account in the calculations performed on this well.

Figure 5 shows the average result for the Crossfield reservoir utilizing the same slope as established by individual well performance. The results of Socony Kathryn No. 3 - 2 were deleted

from this average figure since this well did not fall within the selected proven reservoir.

In developing the deliverability schedule for the Crossfield reservoir a daily maximum allowable of 30% of the absolute open flow was selected. A load factor of 80% was assumed and applied to the daily maximum allowable. The ultimate number of gas wells required over a thirty-year period in order to deliver approximately 5.9 M^3CF annually was found to be 30. This is approximately one well to each 1-3/4 sections of proven Crossfield. At the end of thirty years 53.1% of the initial gas in place will have been produced. Deliverability results from the Crossfield reserves have been estimated, taking into consideration future requirements.

TABLE I

CALGARY FIELD

Estimated Gas Reserves and Reservoir
Date on the Basal Quartz Reservoir.
Gas Volumes Expressed at 14.4 psia and 60° F.

JANUARY, 1958

Reservoir Rock	Lower Cretaceous Sand
Average Depth, feet	7300
Number of Wells now completed (Potential Producers)	2
Total Proven Area, acres	2240
Reservoir Volume, acre feet	19050
Average Porosity, %	15
Average Connate Water, %	25
Average Reservoir Temperature, °F	130
Initial Reservoir Pressure, psia	2900
Compressibility Factor at Initial Conditions	0.801
Specific Gravity of Gas (air = 1.0)	0.699
Initial Gas - Condensate Ratio (Est.), cu. ft/bbl	93,700
Average Net Thickness, ft	8.5
Initial Gas In Place, MCF/acre-ft	1060
Initial Gas in Place, MMMCF	20.20
Recovery Factor, %	85
Depletion Gas In Place, MMMCF	3.02
Recoverable Gas, MMMCF	17.18
Allowance for Shrinkage and Fuel, %	2
Gross Marketable Reserves, MMMCF	16.84

TABLE 11

CALGARY FIELD

Estimated Gas Reserves and Reservoir
Date on the Elkton Reservoir.
Gas Volumes Expressed at 14.4 psia and 60° F.

JANUARY, 1958

	Mississippian
Reservoir Rock	Limestone
Average Depth, feet	7400
Number of Wells now Completed (Potential Producers)	1
Total Proven Area, acres	1130
Reservoir Volume, acre feet	90500
Average Porosity, %	7.25
Average Connate Water, %	25.00
Average Reservoir Temperature, °F	140°
Initial Reservoir Pressure, psia	2985
Compressibility Factor at Initial Conditions	0.832
Specific Gravity of Gas (Air = 1.0)	0.723
Initial Gas - Condensate Ratio (Est.), cu. ft/bbl	52,100
Average Net Thickness, ft	80
Initial Gas in Place, MCF/acre-ft	497
Initial Gas in Place, MMMCF	45.0
Recovery Factor, %	85
Depletion Gas in Place, MMMCF	6.8
Recoverable Gas, MMMCF	38.2
Allowance for Shrinkage and Fuel, %	14
Gross Marketable Reserves, MMMCF	32.85

TABLE 111

CALGARY FIELD

Estimated Gas Reserves and Reservoir
Date on the Crossfield Reservoir.
Gas Volumes Expressed at 14.4 psia and 60° F.

JANUARY, 1958

	Proven	Probable
Reservoir Rock	Devonian Limestone	
Average Depth, feet	8500	
Number of Wells now Completed (Potential Producers)	4	
Total Area, acres	32,000	10,880
Reservoir Volume, Acre Feet	1,792,000	610,000
Average Porosity, %	4.36	
Average Connate Water, %	25.00	
Average Reservoir Temperature, °F	155.00	
Initial Reservoir Pressure, psia	3649	
Compressibility Factor at Initial Conditions	0.641	
Specific Gravity of Gas (Air = 1.0)	0.894	
Initial Gas - Condensate Ratio (Est.), cu. ft./bbl	-----	
Average Net Thickness, ft	56	
Initial Gas in Place, MCF/acre-ft	465	
Initial Gas in Place, MMMCF	834	284
Recovery Factor, %	90.00	90.00
Depletion Gas in Place, MMMCF	84	29
Recoverable Gas, MMMCF	750	255
Allowance for Shrinkage and Fuel, %	59.8	59.8
Gross Marketable Reserves, MMMCF	302	103

TABLE IV

CALGARY FIELD

GAS ANALYSIS

Component	Basal Quartz Volume %	Elkton Volume %	Crossfield Volume %
Methane	84.63	80.26	51.07
Ethane	6.20	6.11	0.57
Propane	2.80	2.70	0.15
Iso-butane	0.43	0.50	0.02
Butane	0.79	0.95	0.04
Iso-pentane	0.36	0.28	0.02
Pentane	0.31	0.30	0.02
Hexane	0.49	0.53	0.12
Nitrogen	Nil	1.64	3.84
Carbon Dioxide	3.99	5.65	10.14
Hydrogen Sulfide	Nil	1.08	34.01

TABLE V

SUMMARY OF GAS ANALYSIS RESULTS

CALGARY FIELD

Well	Formation	Avg. Mol. Weight	Pc	Tc	Gg	Z	Grains H_2S 100 cu. ft Gas
Jefferson Lake C.P.R. North Calgary No. 25-11 (Oct. 8, 1957)	Crossfield	26.28	896.3	460.7	0.907	0.655	18122 (29.12%)
Jefferson Lake C.P.R. North Calgary No. 25-11 (Oct. 10, 1957)	Crossfield	25.73	928.1	477.4	0.887	0.642	20717 (33.29%)
	Crossfield	25.73	934.7	482.0	0.887	0.625	----- (34.01%)
Average		25.91	919.7	473.4	0.894	0.641	(32.17%)
Jefferson Lake C.P.R. North Calgary No. 25-11 (Sept. 10, 1957)	Basal Quartz	20.08	685.4	384.5	0.715	0.790	Nil
Jefferson Lake C.P.R. North Calgary No. 25-11	Basal Quartz	19.76	686.8	383.2	0.682	0.820	Nil
Average		19.92	686.1	383.8	0.699	0.805	Nil
Jeferson Lake C.P.R. North Calgary No. 27-6	Elkton	20.96	696.2	389.9	0.723	0.801	672 (1.08%)

TABLE V1

SUMMARY OF BACK PRESSURE TEST RESULTS

ELKTON

	Net Pay Feet	A.O.F. (MMCF/D)
Jefferson Lake C.P.R. Calgary No.27-6	76	23.5

Average = 0.309 $M^2CF/D/ft.$ of pay

CROSSFIELD

	Net Pay Feet	A.O.F. (MMCF/D)
Jefferson Lake C.P.R. Calgary No.25-11	50	37.2
Socony Calgary No. 36-10	50	28.0
Jefferson Lake C.P.R. Calgary No.27-11	78	7.4
Mobile Oil Chestermere No.18-11	92	5.5
	270	78.1

Average = 0.289 $M^2CF/D/ft.$ of pay

	Net Pay Feet	A.O.F. (MMCF/D)
Socony Kathryn No.3-2	50	2.1

Average = 0.042 $M^2CF/D/ft.$ of pay

Average Open Flow

Basal Quarts = 12.0 M^2CF/D (estimated)

Elkton = 23.5 M^2CF/D

Crossfield = 16.2 M^2CF/D

TABLE VII

BACK PRESSURE TEST RESULTS

ELKTON ZONE

A Jefferson Lake C. P. R. Calgary No. 27 - 6

Nov. 1, 2, 3, 1957

Q (MCF/D)	Pw (PSIA)	(1) Observed B. H. P. (PSIA)	(2) Calculated B. H. P. (PSIA)	(3) Calculated B. H. P. (PSIA)	(1) $Pf^2 - Ps^2$ $(X10^3)$	(2) $Pf^2 - Ps^2$ $(X10^3)$	Stabilization Time (Hours)
0	2364	3030	2940				
10061	1908	2744	2620		1641	1763	8.5
8180	2103	2840	2745		921	1158	3.0
5920	2217	2902	2805		771	766	3.5
4970	2315	2965	2885		381	258	4.5

(1) B. H. Pressures observed with pressure bomb.

(2) Calculations made following "Vitter" procedure.

(3) Calculations made as outlined by R. R. Commission of Texas Back Pressure Testing procedure.

TABLE V111

BACK PRESSURE TEST RESULTS

CROSSFIELD ZONE

A Socony Calgary No. 36 - 10

May 30, 1955

	Q (MCF/D)	Pw (PSIA)	(1) Observed B. H. P. (PSIA)	(2) Calculated B.H.P. (PSIA)	(3) Calculated B. H. P. (PSIA)	(1) Pf^2-Ps^2 $(X10^3)$	(2) Pf^2-Ps^2 $(X10^3)$	(3) Pf^2-Ps^2 $(X10^3)$	Stabilization Time (Hours)
Prior to)	0	2460	*3649	3700					6
Acid)	3140	1664	2534	2500		7200	7442		11
Treatment)	2420	1764	2605	2623		6840	6821		7-1/4
	2205	1839	2705	2715		6310	6342		6
	1110	1999	3205	2925		3340	5149		3-1/4
	554	2331	3405	3420		2020	2062		3-3/4
After)	0	2460		3705	3530				6
Acid)	7840	1928		3123	3195		3900	2270	8-1/4
Treatment)	5970	2131		3293	3220		2800	2110	5
	3260	2344		3443	3320		1600	1450	5-1/2
	2460	2374		3512	3335		1400	1360	5-1/4
	2062	2418		3560	3365		1000	1140	4-3/4
	1452	2453		3590	3380		800	1060	6-3/4
	1112	2444		3588	3395		800	960	5-1/4

B Socony Kathryn No. 3 - 2

May 20, 1954

	Q (MCF/D)	Pw (PSIA)	(1) Observed B. H. P. (PSIA)	(2) Calculated B.H.P. (PSIA)	(3) Calculated B. H. P. (PSIA)	(1) Pf^2-Ps^2 $(X10^3)$	(2) Pf^2-Ps^2 $(X10^3)$	(3) Pf^2-Ps^2 $(X10^3)$	Stabilization Time (Hours)
After)	0	2496		3660					
Acid)	1638	996		1751			10,310		
Treatment)									

$$\text{* Average B.H.P.} = \frac{3700 + 3705 + 3530 + 3660}{4} = 3649 \text{ PSIA}$$

TABLE V111

BACK PRESSURE TEST RESULTS

CROSSFIELD ZONE (Cont'd)

C Jefferson Lake C. P. R. Calgary No. 27 - 11

July 25, 1957

Q (MCF/D)	Pw (PSIA)	(1) Observed B. H. P. (PSIA)	(2) Calculated B. H. P. (PSIA)	(3) Calculated B. H. P. (PSIA)	(1) Pf^2-Ps^2 $(X10^3)$	(2) Pf^2-Ps^2 $(X10^3)$	(3) Pf^2-Ps^2 $(X10^3)$	Stabilization Time (Hours)
0			*3649					
2915	1454		2923			5080		

D Mobile Oil Chestermere No. 18 - 11

Dec. 19, 1957

Q (MCF/D)	Pw (PSIA)	(1) Observed B. H. P. (PSIA)	(2) Calculated B. H. P. (PSIA)	(3) Calculated B. H. P. (PSIA)	(1) Pf^2-Ps^2 $(X10^3)$	(2) Pf^2-Ps^2 $(X10^3)$	(3) Pf^2-Ps^2 $(X10^3)$	Stabilization Time (Hours)
0			*3649					
5079	541		1220			12130		
3519	1069		1680			10800		
2961	1317		1980			9700		
1963	1606		2340			8150		
1371	1862		2690			6380		

E Jefferson Lake C . P. R. Calgary No. 25 - 11

Oct. 10, 1957

Q (MCF/D)	Pw (PSIA)	(1) Observed B. H. P. (PSIA)	(2) Calculated B. H. P. (PSIA)	(3) Calculated B. H. P. (PSIA)	(1) Pf^2-Ps^2 $(X10^3)$	(2) Pf^2-Ps^2 $(X10^3)$	(3) Pf^2-Ps^2 $(X10^3)$	Stabilization Time (Hours)
0	2449		3700					
7160	2260		3460			1680		
6560	2292		3500			1440		2-1/2
5340	2338		3530			1230		3
3215	2396.5		3570			940		2 1/2

(1) B. H. Pressure observed with pressure bomb.

(2) Calculations made following "Vitter" procedure.

(3) Calculations made as outlined by R. R. Commission of Texas Back Pressure Testing Procedure.

TABLE IX

DELIVERABILITY AND DEVELOPMENT SCHEDULE FOR
CROSSFIELD RESERVOIR - CALGARY FIELD
VOLUMES AT 14.4 PSIA AND 60° F

Year	Number of Wells	Daily Max. M^2CF/D	80% Load M^2CF	Annual M^3CF	Cumulative M^3CF	Reservoir Pressure Psia	Reservoir A.O.F. MCF/D	Pipe Line Del. Aver. Day M^2CF/D	Pipe Line Del. Annual M^3CF
1957						3649	16,200		
1958	5	23.05	18.45	6.73	6.73	3620	16,100	7.39	2.70
1959	7	33.80	27.05	9.87	16.60	3580	15,800	10.82	3.95
1960	9	42.60	34.10	12.45	29.05	3520	15,400	13.63	4.97
1961	11	50.80	40.70	14.83	43.88	3425	14,900	16.29	5.94
1962	12	53.70	43.00	15.70	59.58	3330	13,800	17.20	6.28
1963	13	53.80	43.05	15.71	75.29	3220	13,500	17.21	6.28
1964	13	52.60	42.10	15.38	90.67	3145	13,000	16.82	6.14
1965	13	50.70	40.60	14.81	105.48	3065	12,500	16.23	5.83
1966	14	52.50	42.05	15.34	120.82	2975	12,000	16.84	6.15
1967	14	50.40	40.30	14.71	135.53	2900	11,500	16.13	5.89
1968	15	51.75	41.40	15.11	140.64	2862	11,250	16.54	6.04
1969	15	50.70	40.60	14.81	155.45	2790	10,800	16.23	5.92
1970	16	51.80	41.50	15.15	170.60	2715	10,400	16.60	6.06
1971	17	53.10	42.40	15.48	186.08	2650	10,000	16.97	6.19
1972	17	51.00	40.75	14.90	200.98	2585	9,600	16.30	5.95
1973	18	51.90	41.50	15.15	216.13	2530	9,300	16.60	6.06
1974	18	50.20	40.20	14.65	230.78	2470	9,000	16.10	5.88
1975	19	51.30	41.00	14.97	245.75	2415	8,700	16.40	5.98
1976	20	52.15	41.75	15.24	260.99	2360	8,400	16.70	6.10
1977	21	51.60	41.30	15.10	276.09	2315	8,100	16.53	6.04
1978	21	51.00	40.75	14.90	290.99	2260	7,800	16.30	5.95
1979	22	51.50	41.20	15.05	306.04	2210	7,550	16.48	6.02
1980	23	52.10	41.75	15.24	321.28	2160	7,250	16.70	6.10
1981	24	52.20	41.80	15.28	336.56	2110	7,050	16.22	5.92
1982	24	50.75	40.60	14.81	351.37	2065	6,800	16.23	5.92
1983	25	51.00	40.75	14.90	366.27	2015	6,550	16.30	5.95
1984	26	51.10	40.85	14.50	380.77	1980	6,400	16.36	5.97
1985	27	51.80	41.50	15.15	395.92	1925	6,100	16.60	6.06
1986	28	51.30	41.00	14.98	410.90	1870	5,880	16.40	5.98
1987	29	51.10	40.85	14.50	425.40	1828	5,650	16.36	5.97
1988	30	50.80	40.70	14.85	440.25	1775	5,400	16.29	5.95

% Depletion = 53.1%

RESULTS OF BACK PRESSURE TESTS
CALGARY FIELD
JEFFERSON LAKE C.P.R. CALGARY # 27—6
(ELKTON ZONE)

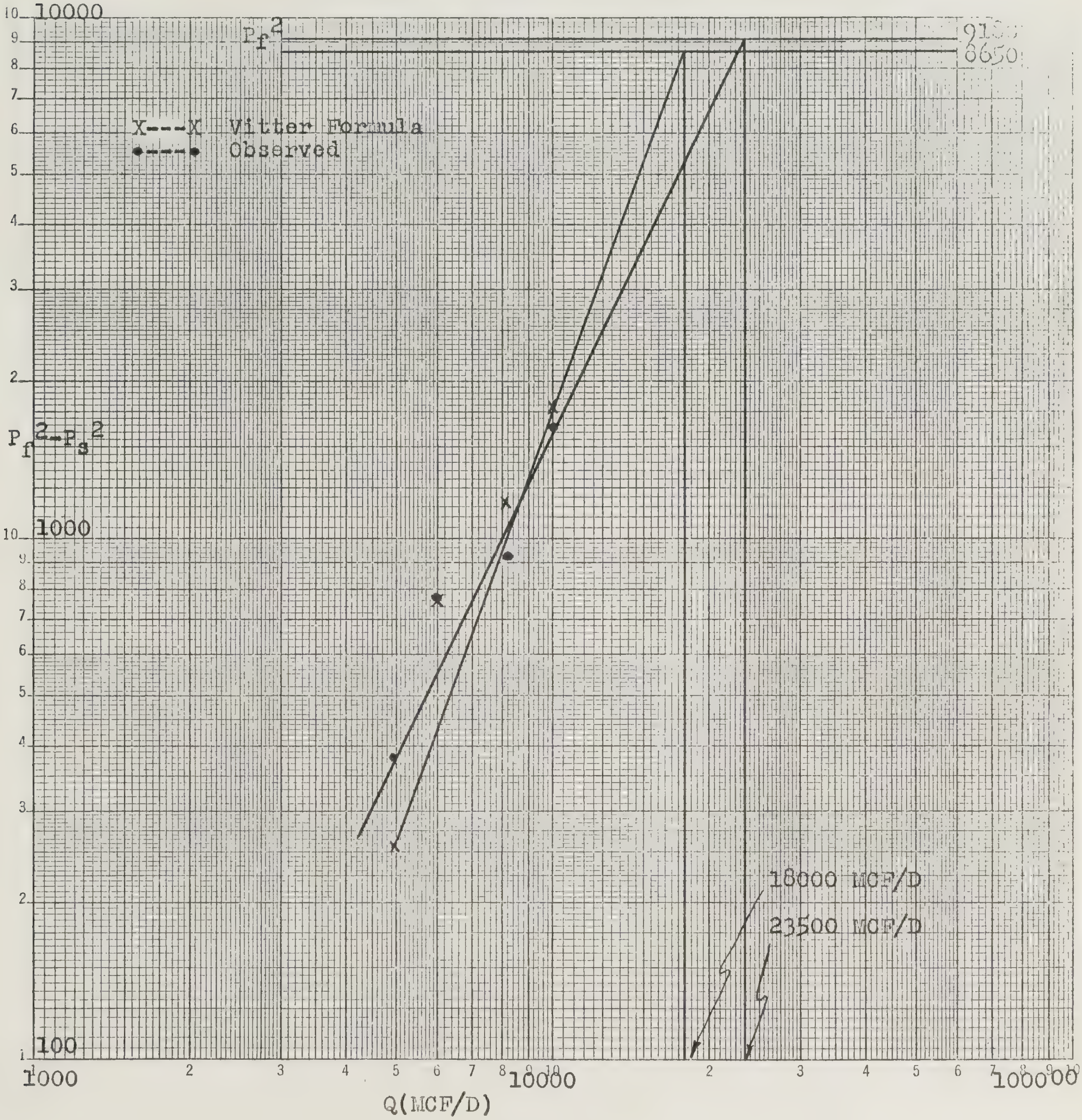


FIGURE 1

RESULTS OF BACK PRESSURE TESTS
CALGARY FIELD
SECONY CALGARY # 36-10
(CROSSFIELD ZONE)

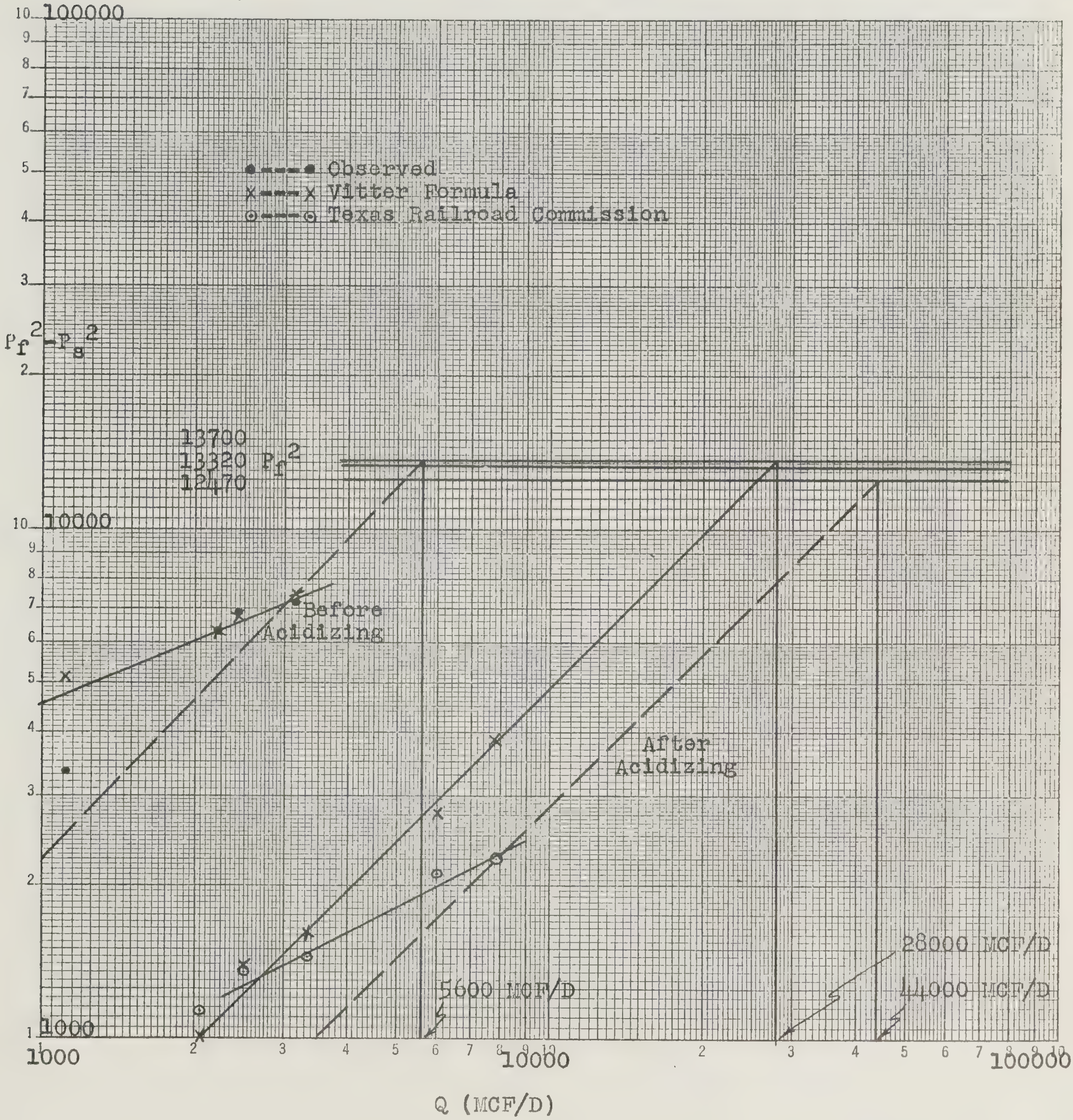


FIGURE 2

RESULTS OF BACK PRESSURE TESTS
CALGARY FIELD
SOCONY KATHRYN # 3—2
JEFFERSON LAKE C.P.R. CALGARY # 27—11
MOBIL OIL CHESTERMERE # 18—11
(CROSSFIELD ZONE)

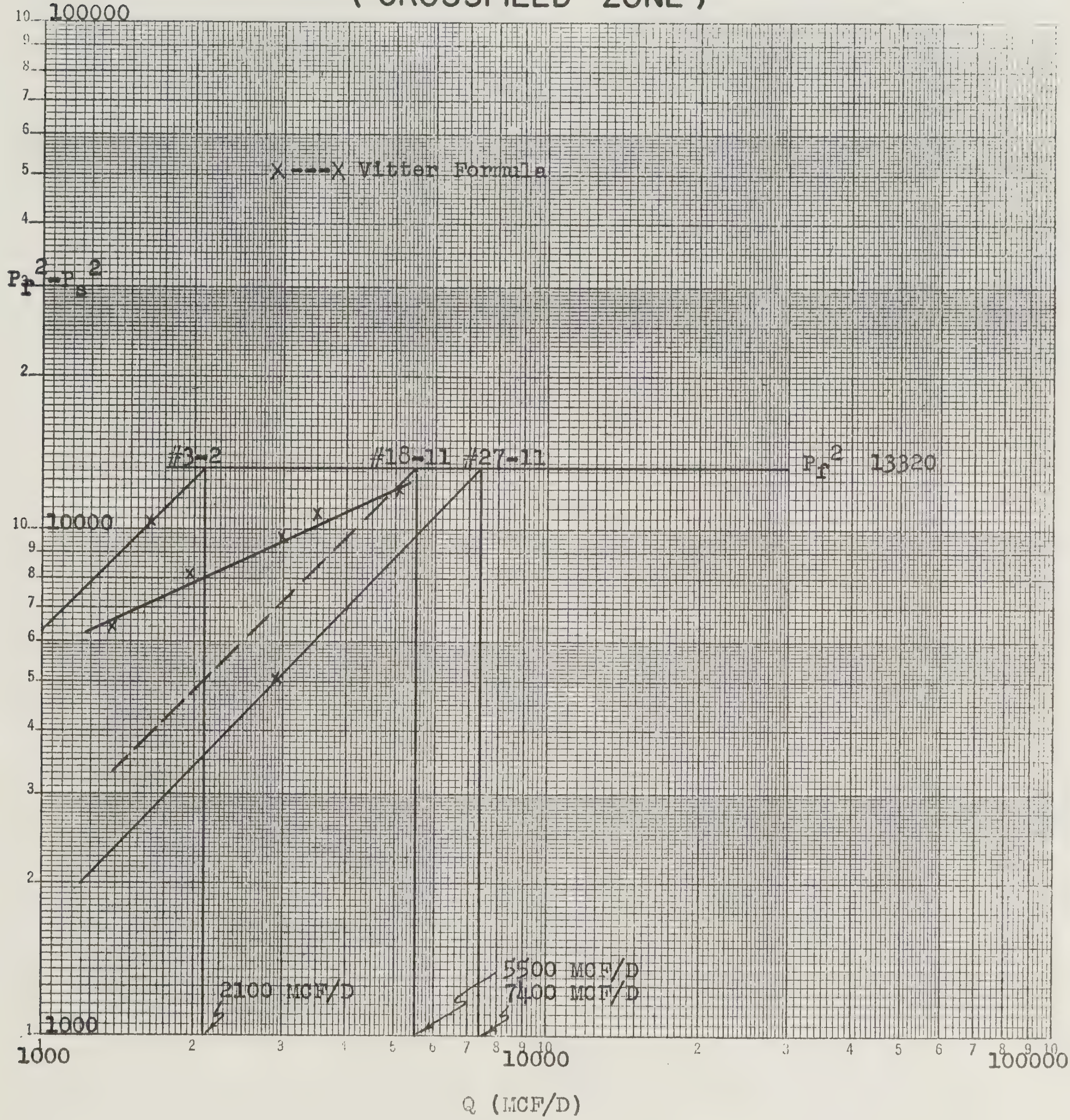


FIGURE 3

RESULTS OF BACK PRESSURE TESTS
CALGARY FIELD
JEFFERSON LAKE C.P.R. CALGARY #25-11
(CROSSFIELD ZONE)

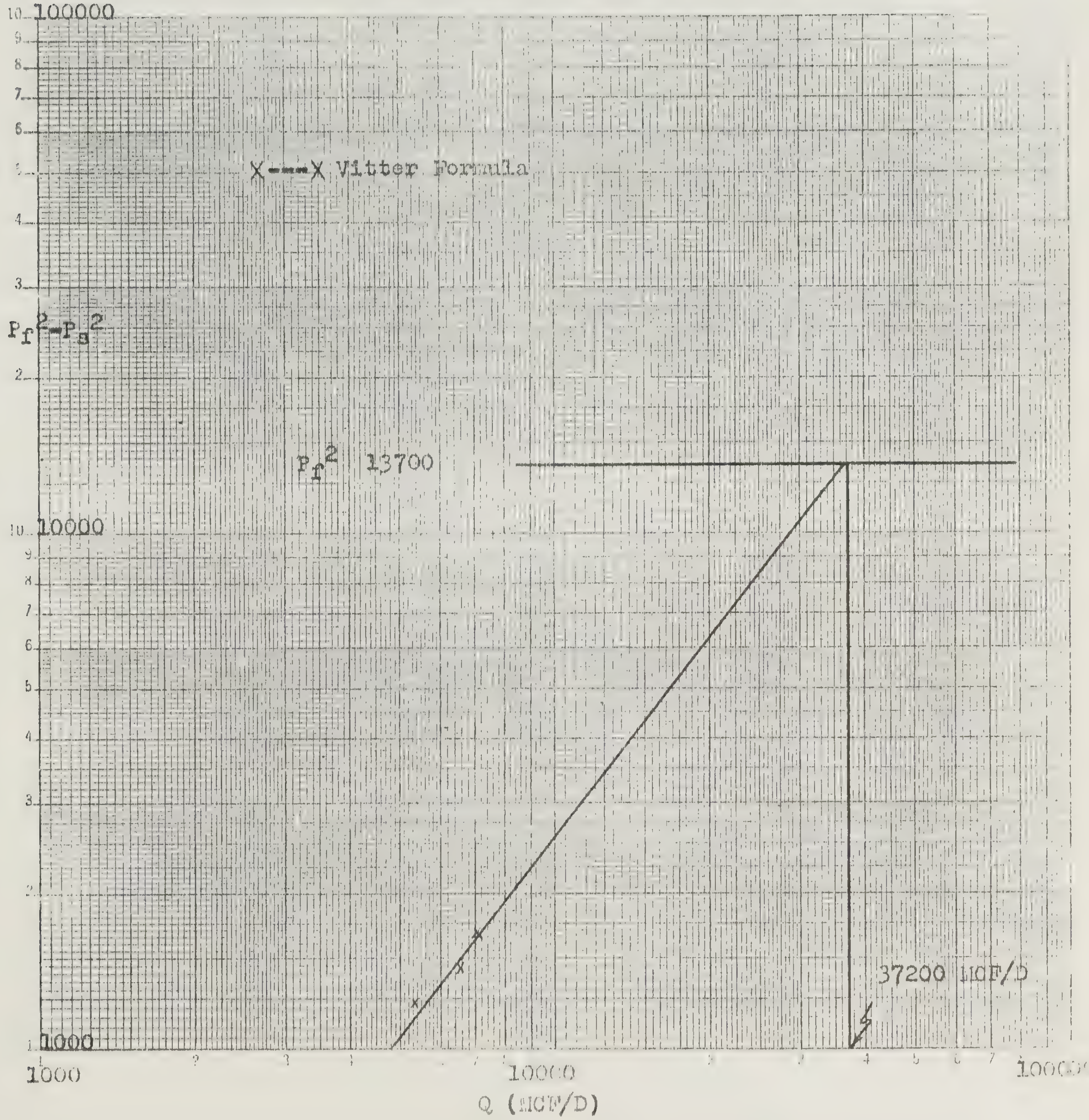


FIGURE 4

AVERAGE BACK PRESSURE RESULTS
CALGARY FIELD
(CROSSFIELD ZONE)

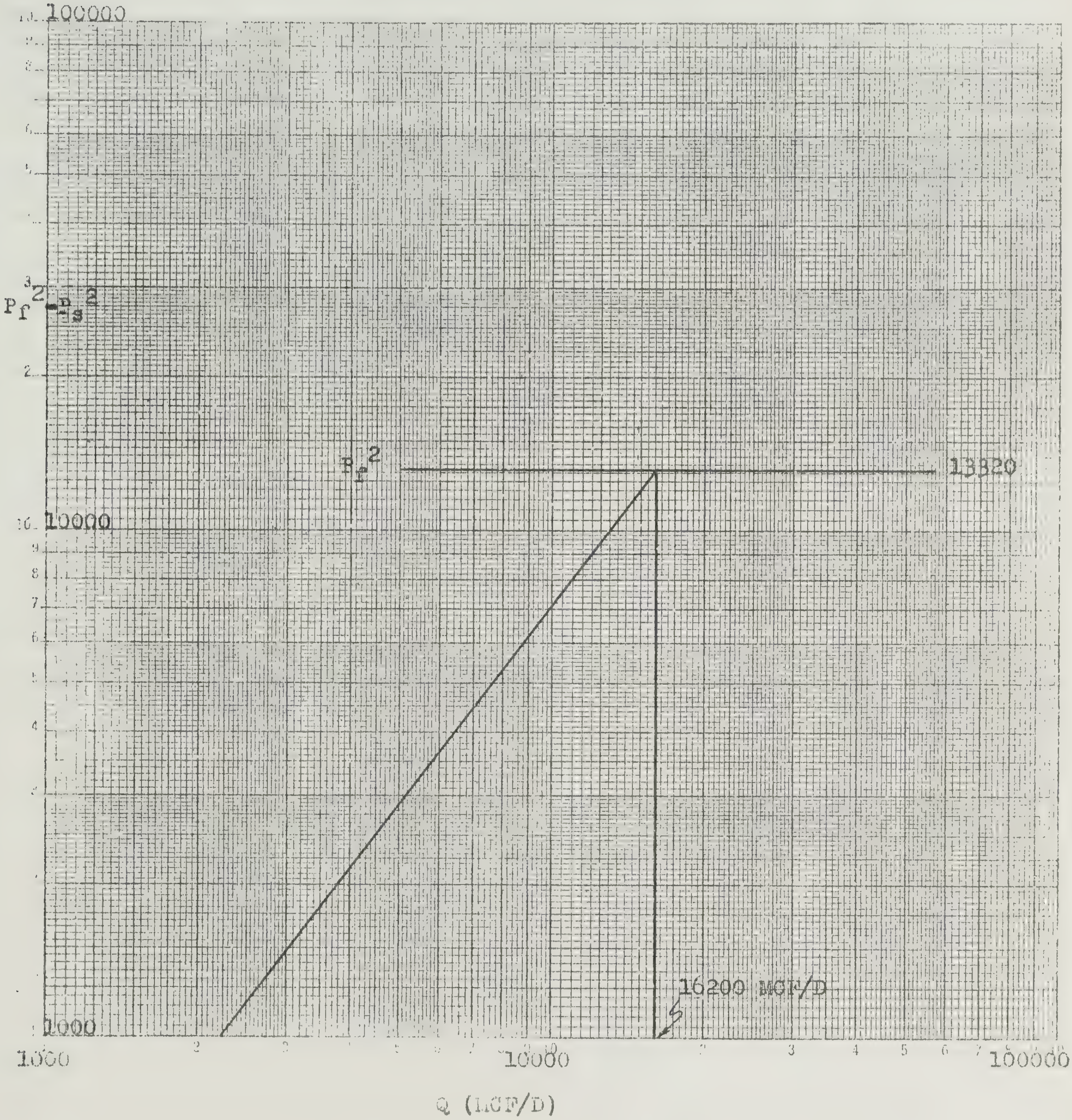


FIGURE 5

PART C

THE POPULATION POTENTIAL OF URBAN CENTRES IN SOUTH-WESTERN ALBERTA AND ITS RELATIONSHIP TO DEMAND FOR NATURAL GAS

INTRODUCTION.

Population growth is a highly unpredictable phenomenon, subject to a great variety of influences which may upset the most well-established patterns and trends. An analytic study of the population of any large urban centre such as Calgary, which, in its short existence, has experienced great and sudden fluctuations ranging from extravagant increases to actual decline, reveals wide variations in the population patterns of specified periods, in the trends of population change from period to period and in the forces and controls which are the external determinants of these patterns and trends. To make valid population projections, then, it is not sufficient to know just the patterns and trends in existence at the time: the possibility of changes in them must also be explored. Predictions must be made of the variations in national and international politics and economics which are likely to affect immigration practices; of the changes in social concepts which may influence birth rates; and of the social and medical advances which may significantly alter death rates and the age structure of the population.

In the case of the Calgary metropolitan area a detailed study on the above lines has been carried out but, unfortunately, there is not sufficient recorded information available to give such a complete treatment to the City of Lethbridge and the several smaller centres also under consideration. Within the limits of existing knowledge, however, the projections made for these centres are perfectly logical and should prove no less acceptable than those for Calgary.

POPULATION PROJECTIONS.

1. Metropolitan Calgary.

A study of the population growth of Calgary reveals two significant trends, a short term and a long term. The long term trend, which can be dated from 1916, after the fever of the land boom subsided, shows that Calgary, through all its vicissitudes, has maintained an average annual increment of three per cent. Since 1948, however, the great post-war immigration boom has created a new trend and the average annual increment has increased to seven per cent. The principal difficulty in estimating Calgary's future

population lies in predicting just how long this increased rate will continue and whether it will cease suddenly or gradually. No indication is given by present statistics. The total population increase from 1956 to 1957 was the equivalent of 7.4% or, excluding the people brought into the City by annexation, 6.5%. This last figure cannot be interpreted as the beginning of a decline, however, because since 1948 the annual increase has ranged from 5.0% to 8.9% with absolutely no pattern at all in the fluctuations.

There are two components of population change which must be considered. The first, natural increase, the balance between births and deaths, is comparatively stable though showing a slight rise over recent years; the other, migration, is highly variable with the balance between immigration and emigration liable to extreme fluctuations. In recent years, however, there has been a very pronounced net immigration balance and it is this which has been largely responsible for the population increase since 1948. Of the seven per cent annual increment, less than one-third (2.25%) has been due to natural increase and as there is, at the present time, no predictable likelihood of a major variation in this rate any change in the pattern will be the result of a change in migration.

The birth rate has recovered from the low level of the depression and war years but now shows only a very slight annual increase which may well be offset in the future by a steadily decreasing family size (from 3.5 persons per family in 1941 to 3.3 persons in 1951). The death rate has been remarkably stable since 1916 and though it has shown a consistent, and latterly quite marked, decrease since 1948 this is largely a reflection of the great influx of young adults and must be expected to increase again as the rate of immigration steadies and the population gradually ages.

Because of the consistency of the death rate, natural increase parallels the more volatile birth rate, showing the same low level of the depression and war years and not until 1955 surpassing the previous high recorded in 1916. If the possibility of further international catastrophes is excluded, however, both birth and death rates seem likely to stabilize at approximately their present levels and, for this reason, the population estimates are based on a continuation of the 2.25% rate of natural increase rather than on a steadily increasing rate.

Immigration, on the other hand, is much more delicately balanced and though officials approached on the matter were not prepared to make any predictions it seems certain that a decrease must be anticipated. On the national scale, immigration is controlled

by the absorptive capacity of the Canadian economy and though people are needed to develop the resource potential of the country it is obvious from the ever-present unemployment problem that large-scale immigration will be carefully regulated. There are already indications of a more restrictive policy towards people of non-British origin and this will undoubtedly affect Calgary, though perhaps not as much as other parts of the country which do not experience the intra-continental movement created by the oil industry. Even this, however, is not likely to be the same force in the future as already the boom days of extravagant expansion have passed and the industry is settling into a more consolidated and stable position.

Because of these factors, the population projections for metropolitan Calgary have allowed for a continuation of the present high annual increment for a further five years to 1962 and from then on are based on the long term increment of three per cent per annum. This anticipates that the present stable rate of natural increase will not be disturbed and provides for an annual net immigration balance increasing from 2,250 in 1962 to 4,465 in 1987, figures which would not seem unreasonable for normal circumstances. Also, despite the apparently sharp decrease after 1962, the projections really provide for a gradually declining rate of population increase between 1960 and 1967, a trend which must be expected as a concomitant of gradually increasing economic stability.

2. City of Lethbridge.

Despite a steady growth in the post-war years, the City of Lethbridge has always been overshadowed by Calgary and its expansion has been largely an expression of the more intensive settlement that irrigation has made possible in its rural hinterland. It has developed almost solely as a service centre for the agricultural region of South-Western Alberta and has not even had the advantages of such industries as utilize agricultural produce. With the recent establishment of regional planning and industrial planning authorities, however, it is expected that the industrial potential of the Lethbridge hinterland, based particularly on its varied mineral and agricultural resources, will be more fully realized and exploited to the benefit of the city and some of its larger subsidiary towns.

Because of this major factor, it is anticipated that Lethbridge's period of greatest expansion is yet to come and that its development during the 1960's will compare with that of Calgary during the present decade. Also like Calgary, it is anticipated that after a boom period of industrial investment there will follow a gradual stabilization, probably early in the 1970's, and that growth from then

on will be due mainly to natural increase supplemented by a certain amount of immigration from the surrounding district.

The population projections for the city of Lethbridge are therefore based on a steadily rising rate of annual increase for the first fifteen year period (from 3.5% per annum in 1957 to 5.0% per annum in 1972) and thereafter at the decreased rate of 2.5% per annum to allow for its more stable and balanced economy.

3. Group "A" Towns - Banff, Claresholm, Cochrane, Granum, High River, and Taber.

All of the small towns in the group listed above are likely to experience considerable growth in the immediate future and, in fact, four of them (Claresholm, Cochrane, Granum and Taber) have already shown exceptional expansion in the period 1946 - 1956. Three of these four are subsidiaries of Lethbridge and as they have quite clearly benefited from the rural intensification brought about by irrigation, it can be expected that they will also share in the industrialization of the Lethbridge region. Of the others, High River and Cochrane are both on national highways and within Calgary's sphere of influence and may well develop as dormitory satellites or "new towns" complete with their own industries, while Banff will almost certainly take on new significance as a transportation and tourism centre with the completion of the Roger's Pass section of the Trans-Canada Highway.

Since 1946, these towns (excluding Banff as statistics were not available) have had an average annual increment of 7.5% and the projections are based on a continuation of this trend until 1967. This allows a ten year period of accelerated development which should be adequate for all the towns except possibly High River, the main development of which may be later as it will depend on a policy of decentralization from Calgary. From 1967, the population of the towns has been projected at an annual rate of three per cent, slightly higher than the Lethbridge rate because the birth rate is significantly higher in the rural centres than in the cities. This rate also allows for a slight immigration balance, drawing on rural areas and nearby static towns.

4. Group "B" Towns - Canmore, Cardston, Exshaw, Fort Macleod, Magrath, Nanton, Okotoks, Picture Butte, Raymond, Stavely, Stirling and Vauxhall.

This second group comprises towns and villages which showed only slight increases between 1946 and 1956 and which are

not expected to experience any outstanding expansion. The average annual increment for these towns is only two per cent, less than the probable rate of natural increase, and they therefore show a net emigration balance. The population projections are based on the continuation of the two per cent annual increase until 1967, because a small number of immigrants (though not enough to offset the emigrants) can be expected during the general period of expansion, and at only one per cent per annum beyond that date as economic consolidation will bring an end to immigration to these towns and a proportionately greater movement from them to the large industrialized towns and cities.

5. Total Population.

The following table gives the estimated 1987 populations of the four urban classifications discussed above.

Metropolitan Calgary	613,304
City of Lethbridge	87,330
Group "A" Towns	50,794
Group "B" Towns	22,739
	774,167

INDUSTRIAL POTENTIAL AND ALTERNATIVE POWER SOURCES.

Although the population statistics provide an invaluable guide to the increase in demand for natural gas, they do not give the complete picture because it has been proved that the relationship between city size and industrialization is not a simple arithmetic one but a geometric one. This means that as a city increases its population its industrial development will increase not in a constant ratio but in a climbing ratio representing a gradually accelerating rate of expansion. The validity of this fact has been established by the American planner, Harland Bartholomew, through an exhaustive study of a large number of United States cities and the following table was adapted from his work.

Population of City	Industrial Land as Percentage of Developed Area
50,000 to 100,000	4.79
100,000 to 250,000	5.84
More than 250,000	8.46

From this evidence it seems obvious that the Calgary of 1987 with its population of 613,000 will have a much higher proportion of industrialization than the present city and therefore a

much higher natural gas consumption than would be expected from a simple comparison with population.

Table 5 gives the value of building permits issued for commercial and industrial premises between 1940 and 1956 and shows quite clearly how these heavy gas consumers have expanded in recent years. Prospects for 1958, with thirty-five million dollars worth of business construction already projected, do not indicate any slackening of the trend and with increasing awareness of the advantages of natural gas as both fuel and raw material for chemical and metallurgical industries and of Calgary's strategic location at the intersection of national and international highways and railways, no such slackening should be anticipated.

A further factor to be taken into account is the possibility of electricity generating stations powered by natural gas instead of the more usual water power. At the end of 1955, Alberta had an installed hydro-electric power capacity of only 212,000 kilowatts (1.6% of total Canadian development) and its potential was estimated at only one million kilowatts, less than 1.9% of the total Canadian potential. It is obvious from these statistics that hydro-electric power is not likely to attain any new significance for Alberta in the future and if, therefore, the electrication of the province is expanded it will be through the construction of thermally powered plants. The two fuels principally used for thermal generation are coal and natural gas, both found in abundance in Alberta, but when a choice between the two is possible it is natural gas which has the outstanding advantages of economy, cleanliness and ease of handling. The future expansion of electric power development will, therefore, also result in an increased demand for natural gas.

CANADIAN WESTERN NATURAL GAS CO. ESTIMATES METROPOLITAN CALGARY.

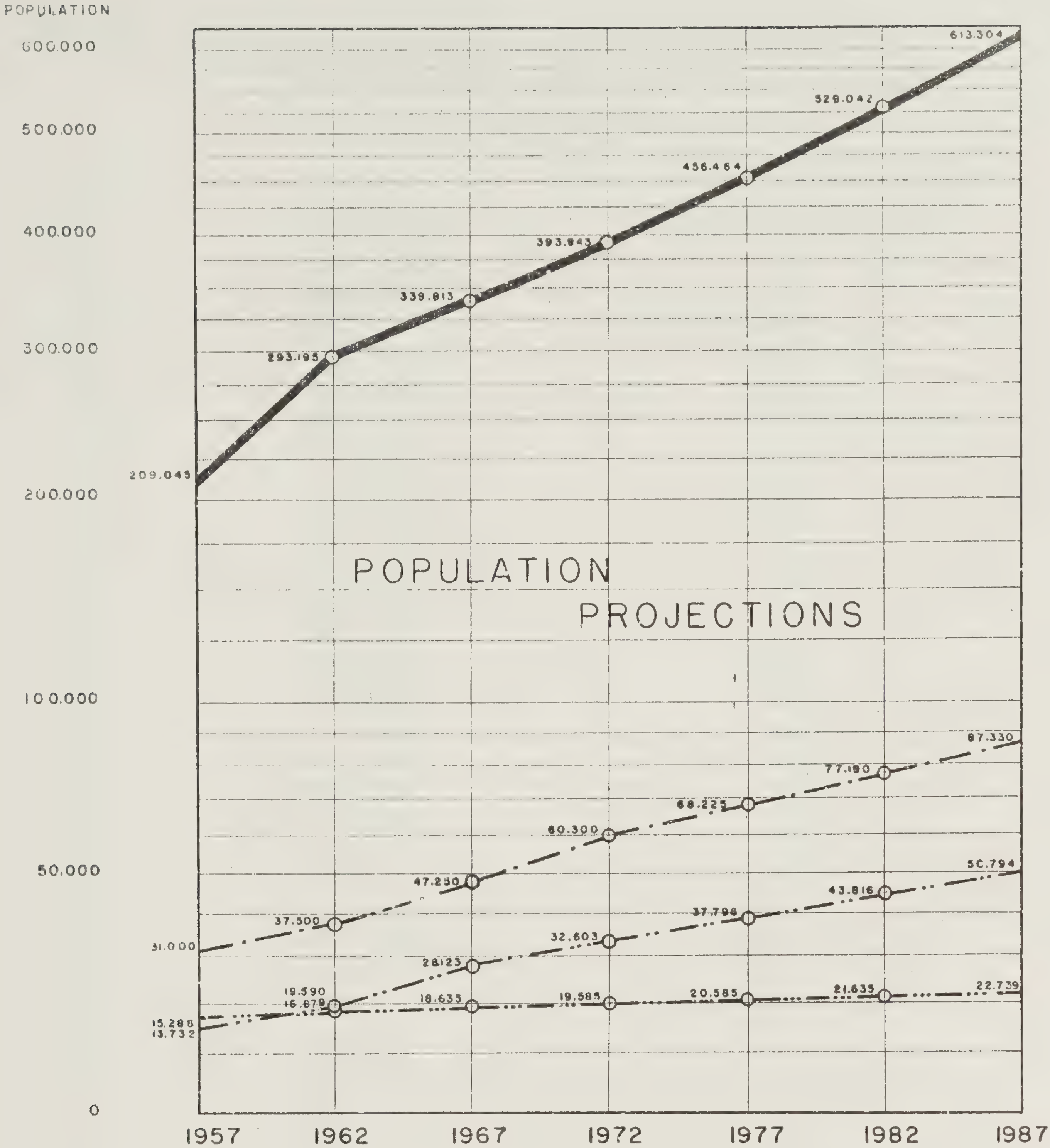
The Company's population projections for Calgary are calculated on a simple arithmetic increase of twelve thousand persons per annum which would result in a population of 564,000 by 1987. This regular increment represents a continuous decline in the rate of growth from 5.0% per annum in 1960, which is rather low on present evidence, to 2.2% per annum in 1986, which is just the expected rate of natural increase and therefore makes no allowance for the immigration attraction of a large city. In the long term, the rate of increase is much more likely to remain constant than the numerical increase and thus provides a more logical basis of estimation.

OTHER CENTRES.

The city of Lethbridge and the towns of groups "A" and "B" above are treated together in the Gas Company's statement along with seventeen other towns and villages. The total projection, which has been arrived at from a simple increment of 4,000 persons per annum, is 197,000 in 1987 and, when allowance is made for the additional towns and for new services which the Company is expecting to start, this comes very close to the Planning Department's estimate of 161,000.

INDUSTRIAL DEMAND.

In the Gas Company's statement provision is made for new industrial demand at the rate of 1,000,000 mcf per annum, once again a constant numerical increase which takes no account of the anticipated acceleration in the rate of industrial development. Furthermore, the company's estimates make no allowance for new major consumers of the order of the three principal plants now in operation which between them use some 10,000,000 mcf per annum. In view of the natural resources of Alberta, this attitude seems more than a little unrealistic.



	METROPOLITAN CALGARY	SEE TABLE 1
	CITY OF LETHBRIDGE	SEE TABLE 2
	GROUP "A" TOWNS	SEE TABLE 3
	GROUP "B" TOWNS	SEE TABLE 4

Table 1 Population Projections - Metropolitan Calgary
(City of Calgary,
Towns of Bowness and Forest Lawn,
Village of Montgomery)

Year	Population	Rate of Annual Increase
1957	209,045	
1958	223,678	7%
1959	239,335	7%
1960	256,088	7%
1961	274,014	7%
1962	293,195	7%
1963	301,991	3%
1964	311,051	3%
1965	320,383	3%
1966	329,994	3%
1967	339,813	3%
1968	350,007	3%
1969	360,507	3%
1970	371,322	3%
1971	382,462	3%
1972	393,843	3%
1973	405,658	3%
1974	417,828	3%
1975	430,363	3%
1976	443,274	3%
1977	456,464	3%
1978	470,158	3%
1979	484,263	3%
1980	498,791	3%
1981	513,755	3%
1982	529,042	3%
1983	544,913	3%
1984	561,260	3%
1985	578,098	3%
1986	595,441	3%
1987	613,304	3%

Table 2 Population Projections - City of Lethbridge

Year	Population	Rate of Annual Increase
1957	31,000	
1958	32,000	3.5%
1959	33,200	
1960	34,500	
1961	36,000	
1962	37,500	
1963	39,200	
1964	41,000	Gradually Increasing
1965	43,000	1957 - 1972
1966	45,000	
1967	47,250	
1968	49,500	
1969	52,200	
1970	55,000	
1971	57,600	
1972	60,300	5 %
1973	61,808	2.5%
1974	63,353	2.5%
1975	64,937	2.5%
1976	66,560	2.5%
1977	68,225	2.5%
1978	69,931	2.5%
1979	71,679	2.5%
1980	73,471	2.5%
1981	75,308	2.5%
1982	77,190	2.5%
1983	79,120	2.5%
1984	81,098	2.5%
1985	83,125	2.5%
1986	85,203	2.5%
1987	87,330	2.5%

Table 3 Population Projections - Group "A" Towns (Banff, Claresholm, Cochrane, Granum, High River, Taber)

Year	Population	Rate of Annual Increase
1957	13,732	
1958	14,762	7.5%
1959	15,869	7.5%
1960	17,059	7.5%
1961	18,338	7.5%
1962	19,590	7.5%
1963	21,059	7.5%
1964	22,638	7.5%
1965	24,336	7.5%
1966	26,161	7.5%
1967	28,123	7.5%
1968	28,973	3 %
1969	29,842	3 %
1970	30,737	3 %
1971	31,659	3 %
1972	32,603	3 %
1973	33,581	3 %
1974	34,588	3 %
1975	35,626	3 %
1976	36,695	3 %
1977	37,796	3 %
1978	38,930	3 %
1979	40,098	3 %
1980	41,301	3 %
1981	42,540	3 %
1982	43,816	3 %
1983	45,130	3 %
1984	46,484	3 %
1985	47,879	3 %
1986	49,315	3 %
1987	50,794	3 %

Table 4 Population Projections - Group "B" Towns (Canmore, Cardston, Exshaw, Fort Macleod, Magrath, Nanton, Okotoks, Picture Butte, Raymond, Stavely, Stirling, Vauxhall)

Year	Population	Rate of Annual Increase
1957	15,288	
1958	15,594	2%
1959	15,806	2%
1960	16,122	2%
1961	16,444	2%
1962	16,879	2%
1963	17,217	2%
1964	17,561	2%
1965	17,912	2%
1966	18,270	2%
1967	18,635	2%
1968	18,821	1%
1969	19,009	1%
1970	19,199	1%
1971	19,391	1%
1972	19,585	1%
1973	19,781	1%
1974	19,979	1%
1975	20,179	1%
1976	20,381	1%
1977	20,585	1%
1978	20,791	1%
1979	20,999	1%
1980	21,209	1%
1981	21,421	1%
1982	21,635	1%
1983	21,851	1%
1984	22,070	1%
1985	22,291	1%
1986	22,514	1%
1987	22,739	1%

Table 5

Value of Building Permits
Issued for Commercial and Industrial Premises
1940 - 1956

Year	Value in Dollars
1940	$ 231,398
1942	283,164
1944	388,714
1946	3,074,157
1948	3,008,833
1950	5,658,045
1952	6,783,352
1954	19,435,335
1956	24,193,802

PART D

Natural Gas Reserves and Deliverability Required for the Calgary-Lethbridge consumers on the Canadian Western Natural Gas Company Limited system for the 30 year period, 1958 - 1987.

By

S. J. Davies, P. Eng.

INTRODUCTION

Three factors are submitted to the Oil and Gas Conservation Board as of essential importance to the gas consumers of the City of Calgary.

They are, first, the cost of gas to space heating, and industrial consumers; second, the dedication of all natural gas reserves, close to either existing treating plants, or to the transmission lines of the Canadian Western Natural Gas Company Limited, to Calgary - Lethbridge - Banff consumers; and finally the provision of adequate new reserves of natural gas to provide deliverability and peak load demands throughout a thirty year period for Calgary - Lethbridge consumers.

ACKNOWLEDGEMENTS

The City of Calgary acknowledges with thanks the co-operation and assistance of the following operating companies and organizations during the examination of geological and other data in preparing this submission:- Mobil Oil Company Limited, Triad Oil Company Limited, Western Leaseholds Limited, Home Oil Company Limited, Consolidated Mining and Smelting Company Limited, Canadian Oil Companies Limited, Jefferson Lake Sulphur Company Limited, Westcoast Transmission Company Limited, Canadian Western Natural Gas Company Limited, and the staff of the Oil and Gas Conservation Board.

DELIVERABILITY TABLE 1

A Deliverability Table covering a thirty year period has been prepared. This may be compared with Exhibit 18 of the Westcoast Transmission Company Limited. The consumption and peak

load data were based upon Exhibit 24, prepared by Canadian Western Natural Gas Company Limited. The changes made in Exhibit 24 are as follows:-
The peak load figure has been brought forward one year, and the interruptible load now in existence was added to the peak load. The Nevis and the Brooks annual consumption and peak load data were separated from that of the Calgary - Lethbridge figures, as both Nevis and Brooks have separate sources of supply. Banff depends upon the Jumping Pound plant for its supply, and must therefore have preference over Calgary - Lethbridge consumers. It has been shown separately.

Mr. A. G. Martin's data on population trends prompted the higher peak load figure used.

Each field shown on the Deliverability Table will be briefly discussed.

TURNER VALLEY

The established reserves of this field as of June 30th, 1956 have been given by the Oil and Gas Conservation Board as follows:-
Rundle Gas Cap 205.0 BCF, and Rundle Solution Gas, 150.0 BCF. Deducting 28 BCF for the eighteen months production to December 31, 1957, the remaining reserves should amount to 327 BCF.

The Home Oil Company has announced a long term water flooding project in the northern crude part of the field. This project should add to the reserves of solution gas; but the amount cannot be estimated until more data are available. Subject to this change the Board's figures on proven reserves in the Turner Valley field have been accepted.

Turner Valley gas has been gathered, compressed, and treated for removal of acid gases by the Madison Natural Gas Company Limited, a public utility, in the northern end of the field; and gathered and compressed in the southern end of the field by British American Utilities Limited.

In the case of both public utilities, the assets on their respective rate bases have been used since 1945. All of the rate base in the case of British American Utilities Limited has been amortized; and some form of annual rental must be considered for the continued use of these assets.

The Madison Natural Gas Company Limited has a rate base; and all its operating expense, maintenance costs, rate of return, and amortization have been divided on a MSCF basis over the marketable gas processed each year. The higher the throughput therefore the lower the cost per MSCF.

Production from Turner Valley will continue to decline. The cost per MSCF to consumers must, therefore, rise unless, by the means of a new source of supply the physical facilities of the Madison Natural Gas Company can be used to near capacity. It is therefore suggested that in 1958, a high pressure 8 5/8 inch O.D., gas gathering line be constructed from the Madison plant in Section 6 TP 20, Rge. 2 W 5 at Turner Valley to the Sarcee Well No 1 in Section 6 TP 23, Rge. 3 W 5. The pipe line distance is about twenty-one miles, and might be a mile longer by the best route.

The Shell well has been standing completed for some time; and more drilling in this very faulted area would be an advantage to consumers of gas. The Shell well was the only productive well of three wells, two were failures. The well has an absolute open flow of 52 MMCF per day, and a closed in pressure of 3765 psia. The area has become known as the Sarcee field, although it is probable that production will be obtained from one or more fault blocks.

It is considered that the Sarcee well should be able to produce 2.5 BCF a year, and a peak load of 10 MMCF without difficulty. The production rate, at the average daily rate for wet gas, amounts to 17.3% of the absolute open flow for the first year. When the pressure drop per million cubic feet of production has been measured, the most effective rate can be determined. It is not likely that all the wells drilled at Sarcee will equal in size the Shell well No 1. The cost of all wells should however be taken into account, when fixing the price of gas in this new area. Consumers must expect to pay the cost of development with a reasonable payout period of well costs.

The south end of the Sarcee structure has been shown on the Deliverability Table as connected to Madison Natural Gas treating plant, at Turner Valley. The reserves of the Sarcee area are considered to amount to 50 BCF proven, and 302 BCF probable. This is based on one section, 640 acres, proven, and 3840 acres of probable production.

JUMPING POUND

The Board has evidence before it, indicating that the capacity of the Shell treating plant at Jumping Pound is to be increased, so that by the year 1959 the annual output will amount to 21.4 BCF marketable gas, and the peak day output increased to 90 MMCF. There is a limited number of wells at Jumping Pound, and the initial absolute open flows were not large, varying from 11 MMCF to 43 MMCF.

Without more detailed data it is impossible to estimate the number of years that Jumping Pound wells could maintain an output of 21.4 BCF, and still maintain 90 MMCF peak day demand. The data may not be available until the production per pound pressure drop has been found under the new projected production rate.

It is quite certain that Jumping Pound could not maintain a production of 21.4 BCF for a long period of years. It is therefore suggested that the northern half of the Sarcee field be tied into the Jumping Pound treating plant with a high pressure gathering line when required. No wells have as yet been drilled on the northern portion of the projected fault block; and no one knows for certain how far the fault block extends to the Northwest. If and when wells are found to be productive they should be connected to Jumping Pound for the purpose of keeping the Jumping Pound plant operating at full capacity, with a peak load of 90 MMCF daily, for as long a period as possible.

The natural gas reserves of the Sarcee field, whatever their size, are requested as a reserve for Calgary - Lethbridge consumers on the Canadian Western system, in order that the treating plants at Jumping Pound and Turner Valley may be kept in operation for as long a period as possible. In the future new sources of supply may be discovered which could be connected to these plants.

The Board's estimate of the Jumping Pound Field of 538 BCF, as of the 30th September 1956, less 21 BCF produced to 31st December 1957, has been accepted, and all of the production from the field is requested for Banff and Calgary - Lethbridge consumers of gas.

CALGARY FIELD

A detailed and careful study of the Calgary field has

been completed and is submitted for the Board's information by Mr. Workman and Dr. Flock.

On the Deliverability Table the production from the Basal Quartz, and Elkton formations has been shown separately from that of the D 1 Devonian production. Only the production now proven in the Jefferson Lake Wells No 27-6 and 25-11 has been included in the Deliverability Table from the Basal Quartz and Elkton formations. This production has been utilized for peak load purposes.

It is possible that the Basal Quartz sand, when depleted, might be useful as a storage area. Its proximity to the Calgary market makes it important. The record of production from the Basal Quartz, which is a most erratic formation, will be watched with great interest.

The need of the Jefferson Lake Sulphur Company for a high load factor of 80% for the D 1 Devonian formation production has been provided for in the Deliverability Table.

All of the production from the Calgary field is requested for Calgary - Lethbridge consumers of natural gas.

OKOTOKS

The Board's estimate of reserves for the Okotoks field has been accepted. The Deliverability Table shows the operation of a sulphur plant at Okotoks on a 100% load factor basis.

There is no actual evidence that this sulphur plant will be built. The Deliverability Table is flexible enough to allow for any delay. More wells would have to be drilled and produced from the Sarcee field at an earlier date than shown, should this plant not be built by 1959.

BOW ISLAND AND FOREMOST

Both of these fields have been shown on the Deliverability Table as storage fields. After repressuring Foremost the gas in storage has been maintained with enough input each year to balance the output. In the future the Lethbridge area will require an increased supply of natural gas. More gas will have to be stored in the summer months, to make sure Lethbridge and other southern towns have an adequate supply of gas in winter.

Both of these fields have a limited storage capacity, but very effective winter deliverability, partly due to a water drive; and partly due to the fairly uniform permeability, and good porosity of the Bow Island sand.

The initial reserves of both these fields were small, around 35 BCF for Bow Island, and 21 BCF for Foremost, yet both fields have proven to be valuable storage areas. It is therefore not the size of the storage area, but rather the type of geological formation which is of first importance in selecting any new storage area. In this regard the actual record of production from the wells in the area is required, before any decision can be made as to the suitability of any geological horizon for storage of natural gas.

SUNDRE - WESTWARD HO - HARMATTAN - CROSSFIELD AREA

From the Deliverability Table it will be noted that a production from this area of 843.2 BCF has been shown over a 25 year period commencing in 1963, with the initial peak load demand of 50 MMCF, rising to 400 MMCF per day in 1987.

A paper in the November 1957 issue of the Journal of the Alberta Society of Petroleum Geologists, by C. R. Hemphill, has been included with this submission. Extensive use has been made of the data contained in the paper by Mr. Hemphill, and the City of Calgary wishes to thank him for the permission to use these data.

It has been concluded from the oil reserve data, given by Mr. Hemphill, that the oil reserves will not be exhausted under a 20 year period. This means that the gas cap gas cannot be made available for Calgary - Lethbridge requirements until 1983, or perhaps even a later date, if present restrictions on marketing crude oil in the United States are continued.

The oil fields are separated by lithological barriers. The area of the gas cap associated with each oil field is not definitely known. From the detailed work done on the Elkton formation in the Calgary field, there is reason to conclude that gas fields will be found quite separate to the gas cap areas associated with each oil field. These are not known at present, as there have not been sufficient wells drilled to enable anyone to do more than speculate on the possibilities.

The Calgary - Lethbridge consumers cannot depend upon gas reserves which are not known. Gas reserves are therefore

needed for the Calgary - Lethbridge consumers, which are not associated with the Sundre - Westward Ho - Harmattan - Crossfield group of oil fields. The Elkton gas in the area from Calgary to Sundre will be needed by Calgary - Lethbridge consumers when it is available for use.

There is a possibility that within the next five years new sources of supply may be found, which would be large enough to provide a low load factor market with sufficient gas for the period, before the Sundre - Westward Ho - Harmattan - Crossfield gas cap gas can be made available.

Another possible way of providing the necessary gas supplies is to define the limits of the gas cap for each oil field; and permit the production of gas from areas not within the limits defined by the Board as associated gas. A detailed geological and Engineering study might disclose that there was in fact sufficient gas of a non-associated classification to provide the necessary gas supply required by the Calgary market, beginning in the year 1963. Sufficient time was not available to make such a study when preparing this submission. This problem should be solved without causing an excessive increase in rates to the consumers of gas in Calgary.

INTERRUPTIBLE CONSUMERS

There is at present one interruptible contract in effect on the Canadian Western system in the southern part of the province.

By the year 1961 fuel oil is going to be more plentiful in supply at Calgary, as the railway dieselization program will be near completion. This fuel oil will be sold. Rather than lose large consumers to fuel oil, it is good business to encourage large space heating consumers to use other types of fuel during very cold weather. Such consumers should not be expected to pay any part of peak load demand costs; and their rates should compare with the industrial high load factor schedule of rates when the quantity of fuel used qualifies such consumers for equivalent rates.

Deficiencies, in years when treating plant expansion became necessary, have been covered by interruptible consumers to the extent of the deficiency during any peak load period.

In the near future a thermal power plant will become necessary for Calgary. Such a plant, which will have a high December peak load, should have a duplicate fuel supply system built

in; so that it may have the full benefit of a low natural gas rate, and at the same time provide the space heating consumers with the benefit of interruptible load during very cold peak day periods.

LOAD FACTOR IN ALBERTA

The average load factor in the climate of Alberta approximates 35%. It may be calculated for any year by the formula annual BCF x 10^9 divided by (365 multiplied Peak day MMCF x 10^6).

Space heating consumers of gas in Alberta have for over forty years paid the cost of gas with a 35% load factor.

Interruptible load consumers, high load factor industrial consumers, and storage fields all help to modify the cost of the 35% load factor. Nothing, however, will change a 35% load factor space heating climate into a 70% load factor space heating climate.

TREATING PLANT

The next treating plant should be built near Calgary. With modern dehydration units at wells, or for groups of wells, raw gas may be transported from any part of the Sundre to Calgary area by one gathering system.

A number of small treating plants spread over a distance sixty miles long between Sundre and Calgary would be expensive.

The light fractions and acid gases can be transported through such a gathering system, and a properly designed plant may be expanded as required by the increase in market and peak load demand. The hydrogen sulphide may be sold to the Jefferson Lake Sulphur plant for recovery of elemental sulphur. The light Fractions become available in one place in sufficient amounts, where they may be combined with the light fractions from the Turner Valley and Jumping Pound plants, and similar production from refinery operations. They are available for petrochemical manufacturers, or for fuel.

CONCLUSION

A summary of the reserves available, and the quantity used from each reserve during the 30 year period, from 1958 to 1987

inclusive, has been made.

	RESERVES BCF	USED BCF
Turner Valley	327*	298.2
Sarcee	352	352
Jumping Pound	517*	436.8
Calgary, Elkton and Basal Quartz	49.7	28.7
Calgary Devonian	405.	159.3
Okotoks	155	155.4
Sundre - Harmattan - Crossfield - Elkton gas	1220*	843.2
Carbon	206	
	3231.7	2273.6

*Board's estimate

The Sarcee reserve is needed in the year 1958, and drilling should be continued on this structure as additional reserves must be obtained for both the Madison Turner Valley Plant, and the Shell plant at Jumping Pound.

By 1959 the by-product gas from the Devonian at Okotoks is needed.

A further supply of by-product gas from the high sulphur Devonian reserve is added from the Calgary field in 1961. By 1963 all the reserves of gas close to Calgary will have been connected except those in the area from Calgary to Sundre. This gas is at present classified as gas cap gas. It is not available for consumption until the crude oil, with which it is associated, has been produced. This may mean a delay of twenty years for most of the gas in this area. Calgary will need a new, low load factor supply of large size, beginning in the year 1963, if enough nonassociated low sulphur content gas cannot be obtained from the Sundre - Harmattan - Crossfield area.

Consumers of gas in Alberta must expect to pay producers a price which will encourage the drilling of gas wells as fast as needed. A payout period of not longer than four years for the average well should provide sufficient incentive to the producers.

The City of Calgary has not asked for the dedication of

any gas reserves it is not prepared to see connected to the Canadian Western system as fast as it can be developed; or as fast as the Oil and Gas Conservation Board will permit the reserve to be produced.

he load factor of space heating consumers in Canada is around 35%. Nothing can materially change this figure because it is caused by the climate of Canada. The Oil and Gas Conservation Board controls the production of crude oil, and decides the amount of oil each well in any oil field may produce and sell. The Board should have the same authority over the production of natural gas, without changing the price consumers pay for it. Some gas fields may be produced at 35% load factor, others due to high sulphur content may need a load factor of 80%. Oil field solution gas may be produced at a load factor of 100% or higher.

Load factor is defined as the average consumption per year divided by the peak day consumption during the year.

It is stated with emphasis that no penalty should be placed upon Canadian consumers by reason of the climate of Canada. No foreign, or Canadian corporation should have the power to discriminate against Canadian consumers in favour of foreign consumers by means of a load factor penalty. Canadian consumers have to pay enough in the number of wells, larger gathering lines, and larger treating plants, needed to supply gas during cold winter months.

Allocation of supplies of natural gas from different fields should be under the control of the Oil and Gas Conservation Board, and without contract restrictions. Should the production of sulphur become unprofitable, or the sale of sulphur to United States market become subject to quota, or be restricted, in a similar manner to the quota recently placed on crude oil by the United States, sulphur producing plants, such as those proposed at Calgary and Okotoks, may restrict production, or even shut down. In this event new sources of low sulphur content gas, such as that found in the Elkton formation between Sundre and Calgary, would need to be allocated to Calgary consumers by the Board.

It is clear that Calgary - Lethbridge consumers must not depend upon oil field solution gas, or high acid content gas to any large extent. The basic supply must come from low acid gas content fields, preferably not associated with crude oil production.

A very large supply of gas is needed in the latter half of the thirty year period. The peak day figure reaches 710 MMCF a day by 1987. It is necessary to consider where this amount of gas

is going to come from, before the year 1972. New discoveries will no doubt make up an important part; but treating plants must also be considered. It is for this reason that the suggestion has been made that the next treating plant be planned, so that its capacity may be increased from time to time; and that it be built at Calgary.

The plan set out in the Deliverability Table provides the lowest cost gas to consumers. Nearly all the 10 3/4¢ per MSCF gas is used. The two treating plants at Jumping Pound and Turner Valley are utilized to their maximum peak load capacity for the full thirty years. All the gas fields within economic distance of these treating plants have been used. The combination of all these factors makes a flexible and economic operation from the consumers point of view.

The problem of the amount of non-associated gas in the Sundre - Westward Ho - Harmattan - Crossfield area remains to be determined.

Every effort has been made to supply data which it is hoped may be of assistance to the Board.

All of which is respectfully submitted.

"S. J. DAVIES"

S. J. Davies, P. Eng.

7 January 1958.

CANADIAN WESTERN NATURAL GAS CO. LTD. SYSTEM

DELIVERABILITY TABLE 1958 TO 1987

	Canadian Western Requirement Exhibit 24		Deduct Nevis		Deduct Brooks		Deduct Banff		Calgary-Lethbridge Requirement		Turner Valley		Sarcee via Madison		Sarcee via Jumping Pound		Jumping Pound		South Storage Fields		Calgary Basal Quartz and Elkton		Calgary D1 Devonian		Okotoks D1 Devonian		Sundre-Harmattan-Crossfield		Deliverable Gas		Surplus		Interruptible Consumption (Deficiency)	
Year	Annual BCF	Peak Day MMCF	Annual BCF	Peak Day MMCF	Annual BCF	Peak Day MMCF	Annual BCF	Peak Day MMCF	Annual BCF	Peak Day MMCF	Annual BCF	Peak Day MMCF	Annual BCF	Peak Day MMCF	Annual BCF	Peak Day MMCF	Annual BCF	Peak Day MMCF	Annual BCF	Peak Day MMCF	Annual BCF	Peak Day MMCF	Annual BCF	Peak Day MMCF	Annual BCF	Peak Day MMCF	Annual BCF	Peak Day MMCF	Annual BCF	Peak Day MMCF	Annual BCF	Peak Day MMCF	Annual BCF	Peak Day MMCF
1958	38.4	264.0	1.1	9.0	0.22	1.8	4.2	16.0	32.8	237.2	16.6	85.0	1.0	10.0			17.1	64.0	(2.1)	55.0	0.2	12.0							34.9	226.0	2.1			11.2
1959	40.7	282.0	1.1	9.0	0.23	1.8	4.3	16.4	35.1	254.8	16.5	85.0	2.5	10.0			16.7	73.6	(2.5)	55.0	0.5	12.0			1.4	15.0			37.6	250.6	2.5			4.2
1960	45.5	308.0	1.2	9.0	0.24	1.9	4.3	16.8	39.8	280.3	16.5	85.0	2.5	10.0			15.7	73.2	(1.4)	55.0	1.0	32.0			5.5	15.0			41.2	270.2	1.4			10.1
1961	48.1	324.0	1.2	9.0	0.25	2.0	4.4	17.3	42.2	295.7	15.5	85.0	2.5	10.0			15.7	72.7	(3.9)	55.0	1.0	32.0	5.9	20.0	5.5	15.0			46.1	289.7	3.9			6.0
1962	50.7	339.0	1.3	10.0	0.26	2.1	4.4	17.6	44.7	309.3	15.5	75.0	3.5	20.0			15.7	72.4	(2.4)	55.0	1.0	32.0	5.9	20.0	5.5	15.0			47.1	289.4	2.4			19.9
1963	53.3	355.0	1.3	10.0	0.27	2.2	4.4	17.9	47.3	324.9	14.4	75.0	5.0	20.0			15.0	72.1		55.0	1.0	32.0	5.9	20.0	5.5	15.0	0.5	50.0	47.3	339.1		14.2		
1964	55.9	371.0	1.4	11.0	0.28	2.2	4.5	18.2	49.8	339.6	14.4	75.0	5.0	20.0	2.5	10.0	10.0	61.8		55.0	1.0	32.0	5.9	20.0	5.5	15.0	5.5	50.0	49.8	338.8				0.8
1965	58.4	387.0	1.4	11.0	0.29	2.3	4.5	18.5	52.2	355.2	14.4	75.0	5.0	20.0	2.5	10.0	10.0	61.5		55.0	1.0	32.0	5.9	20.0	5.5	15.0	7.9	50.0	52.2	338.5				16.7
1966	61.0	402.0	1.5	11.7	0.30	2.3	4.6	18.9	54.6	369.1	14.4	75.0	5.0	20.0	2.5	10.0	10.0	61.1		55.0	1.0	32.0	5.9	20.0	5.5	15.0	10.3	100.0	54.6	388.1		19.0		
1967	63.5	418.0	1.5	11.7	0.31	2.4	4.6	19.3	57.1	384.6	12.0	65.0	7.5	30.0	5.0	20.0	10.0	50.7		55.0	1.0	32.0	5.9	20.0	5.5	15.0	10.2	100.0	57.1	387.7		3.1		
1968	66.1	434.0	1.5	12.6	0.32	2.5	5.7	21.7	58.5	397.2	12.0	65.0	7.5	30.0	7.5	30.0	8.2	38.3		55.0	1.0	32.0	5.9	20.0	5.5	15.0	10.9	100.0	58.5	385.3				11.9
1969	68.7	450.0	1.6	12.6	0.33	2.6	5.7	22.6	61.1	412.2	12.0	65.0	7.5	30.0	7.5	30.0	8.2	37.4		55.0	1.0	32.0	5.9	20.0	5.5	15.0	13.5	100.0	61.1	384.4				27.8
1970	71.3	465.0	1.6	12.6	0.34	2.6	5.7	23.2	63.7	426.6	12.0	65.0	7.5	30.0	7.5	30.0	8.2	36.8		55.0	1.0	32.0	5.9	20.0	5.5	15.0	16.1	150.0	63.7	433.8		7.2		
1971	73.8	481.0	1.7	13.0	0.35	2.7	5.8	23.7	65.9	441.6	12.0	65.0	7.5	30.0	7.5	30.0	8.1	36.3		55.0	1.0	32.0	5.9	20.0	5.5	15.0	18.4	150.0	65.9	433.3				8.3
1972	76.4	497.0	1.7	13.0	0.36	2.8	5.8	24.3	68.5	456.9	12.0	65.0	7.5	30.0	7.5	30.0	8.1	35.7		55.0	1.0	32.0	5.9	20.0	5.5	15.0	21.0	150.0	68.5	432.7				24.2
1973	79.0	513.0	1.8	14.0	0.37	2.9	5.9	24.9	70.9	471.2	12.0	65.0	7.5	30.0	7.5	30.0	8.0	35.1		55.0	1.0	32.0	5.9	20.0	5.5	15.0	23.5	200.0	70.9	482.1		10.9		
1974	81.5	529.0	1.8	14.0	0.38	3.0	6.0	25.7	73.3	486.3	10.0	65.0	7.5	30.0	7.5	30.0	7.9	34.3		55.0	1.0	32.0	5.9	20.0	5.5	15.0	28.0	200.0	73.3	481.3				5.0
1975	84.1	544.0	1.9	15.0	0.39	3.1	6.1	26.2	75.7	499.7	10.0	65.0	7.5	30.0	7.5	30.0	7.8	33.8		55.0	1.0	32.0	5.9	20.0	5.5	15.0	30.5	200.0	75.7	480.8				18.9
1976	86.7	561.0	1.9	15.0	0.4	3.1	6.2	26.8	78.2	516.1	10.0	65.0	7.5	30.0	7.5	30.0	7.7	33.2		55.0	1.0	32.0	5.9	20.0	5.5	15.0	33.1	200.0	78.2	480.2				35.9
1977	89.3	576.0	2.0	15.4	0.42	3.2	6.3	27.4	80.6	530.0	10.0	65.0	7.5	30.0	7.5	30.0	7.6	32.6		55.0	1.0	32.0	5.9	20.0	5.5	15.0	35.6	300.0	80.6	579.6		49.6		
1978	91.8	590.0	2.0	15.4	0.44	3.4	7.2	30.8	82.2	540.4	5.0	65.0	7.5	30.0	7.5	30.0	6.7	29.2		55.0	1.0	32.0	5.9	20.0	5.5	15.0	43.1	300.0	82.2	576.2		35.8		
1979	94.4	607.0	2.1	17.0	0.46	3.6	7.3	31.7	84.5	554.7	5.0	65.0	7.5	30.0	7.5	30.0	6.6	28.3		55.0	1.0	32.0	5.9	20.0	5.5	15.0	45.5	300.0	84.5	575.3		20.6		
1980	96.9	623.0	2.1	17.0	0.48	3.8	7.4	32.1	86.9	570.1	5.0	65.0	7.5	30.0	7.5	30.0	6.5	27.9		55.0	1.0	32.0	5.9	20.0	5.5	15.0	48.0	300.0	86.9	574.9		4.8		
1981	99.5	639.0	2.2	17.5	0.50	3.9	7.5	32.6	89.3	585.0	3.0	65.0	7.5	30.0	7.5	30.0	3.0	27.4		55.0	1.0	32.0	5.9	20.0	5.5	15.0	55.9	300.0	89.3	574.4				10.6
1982	102.1	655.0	2.2	17.5	0.52	4.0	7.6	33.7	91.8	599.8	3.0	65.0	7.5	30.0	7.5	30.0	3.0	26.3		55.0	1.0	32.0	5.9	20.0	5.5	15.0	58.4	300.0	91.8	573.3				26.5
1983	104.6	670.0	2.3	18.0	0.53	4.2	7.7	34.7	94.1	613.1	3.0	65.0	7.5	30.0	7.5	30.0	3.0	25.3		55.0	1.0	32.0	5.9	20.0	5.5	15.0	60.7	400.0	94.1	672.3		59.2		
1984	107.2	687.0	2.3	18.0	0.55	4.4	7.8	35.7	96.5	628.9	3.0	65.0	7.5	30.0	7.5	30.0	3.0	23.9		55.0	1.0	32.0	5.9	20.0	5.5	15.0	63.1	400.0	96.5	670.9		42.0		
1985	109.8	702.0	2.4	19.0	0.57	4.6	7.9	36.7	98.9	641.7	3.0	65.0	7.5	30.0	7.5	30.0	3.0	21.5		55.0	1.0	32.0	5.9	20.0	5.5	15.0	65.5	400.0	98.9	668.5		26.8		
1986	112.4	718.0	2.4	19.0	0.59	4.8	8.1	38.5	101.3	655.7	3.0	65.0	7.5	30.0	7.5	30.0	3.0	19.7		55.0	1.0	32.0	5.9	20.0	5.5	15.0	67.9	400.0	101.3	666.7		11.0		
1987	115.0	735.0	2.5	20.0	0.60	4.9	8.4	40.7	103.5	669.4	3.0	65.0	7.5	30.0	7.5	30.0	3.0	17.5		55.0	1.0	32.0	5.9	20.0	5.5	15.0	70.1	400.0	103.5	664.5				4.9
TOTALS	2326.1		53.0		11.55		180.3		2081.0		298.2		189.5		162.5		256.5		(12.3)		28.7		159.3		155.4		843.2		2093.3		12.3			